THE JOURNAL OF ENGINEERING EDUCATION

VOLUME 35 NUMBER 3

Contents for November, 1944

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Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the Society for the Promotion of Engineering Education under the Supervision of the Publication Committee: F. L. Bishop, Chairman, University of Pittsburgh, Robert E. Doherty, and H. S. Rogers. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the Act of August 12, 1912. Subscription Price, $3.00 per year; Single Copies, 50 cents.

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St. Louis, Mo.
June 21–24, 1945

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The 1945 Meeting

The 53rd annual meeting of the Society for the Promotion of Engineering Education will be held in the Jefferson Hotel, St. Louis, Missouri, June 21–24, 1945, with Washington University our host. Dean A. S. Langsdorf is General Chairman and has appointed the following committees:

Hotels and Rooms	Lawrence E. Stout
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The program for this meeting is in charge of the following committee: H. S. Rogers, Chairman, N. W. Dougherty, H. M. Crothers, F. L. Bishop and J. S. Thompson.

The 1945 S.P.E.E. Meeting

The attention of members of the Society is directed to the fact, announced in the September issue of the *Journal,* that the next annual meeting will be held in St. Louis under the auspices of Washington University, June 21–24, inclusive.

Because of lack of sufficient housing accommodations on the University Campus, and because of the further fact that summer session classes would seriously interfere with meetings in the University buildings, arrangements have been made to follow the precedent set at the Cincinnati meeting, and general headquarters and most of the meetings will be held at the Jefferson Hotel which has the great advantage of providing ample air-conditioned rooms for meetings, luncheons, and dinners. At least one of the general sessions will be arranged on the University Campus.

A local committee under the Chairmanship of Dean A. S. Langsdorf is in process of organization. Any inquiries concerning arrangements for meetings may be addressed to him.

The last meeting of the S.P.E.E. held in St. Louis occurred in the fall of 1904 at the time of the Louisiana Purchase Exposition.

It is hoped that by the time of the meeting it may be possible to arrange inspection trips of the numerous points of interest in and around the city.

A. S. LANGSDORF
General Chairman

Basic Consideration in a Program of Freshman Evaluation*

By K. W. VAUGHN

Director, Measurement and Guidance Project in Engineering Education

Introduction

Whatever changes in engineering education occur as a result of the present war, there is one fundamental consideration which must always be kept in the foreground. This is the fact that the quality, standing, and importance of any profession depend largely upon the quality and competence of the men who constitute it. High-caliber men make a profession; professional training does not necessarily make high-caliber men. It follows then that colleges of engineering must insure that those who become professional engineers are the kinds of trained men who will not only maintain but advance their chosen profession. This implies a carefully designed program of selection for and guidance through an engineering curriculum, which, when properly organized and implemented, will equip the graduate engineer with professional qualities and capacities. This is the general purpose of engineering education. This conference is mute testimony that engineering educators are keenly aware of their responsibilities and deeply interested in improving the many aspects of engineering education.

The Measurement and Guidance Project, which is the principal subject of discussion this afternoon, is concerned primarily with the problems of selecting engineering students and with the development of objective examinations to assist in their selection, placement, and guidance. Our studies are directed at the "bottleneck" of the profession, that is, the point at which the student establishes his first contact with the engineering profession.

The Project has been in existence for one year; it was formally approved by the S.P.E.E., the E.C.P.D., and the Carnegie Foundation in June of 1943 and began active work on July 1 of that year. During the first year of its existence, it achieved two of its primary objectives. In the first place, the past year has seen the development of an experimental battery of selection and guidance tests known as the *Pre-Engineering Inventory* which was discussed at some length in a recent issue of this JOURNAL.* This test battery was administered experimentally to more than 4,500 freshman engineering students and on the basis of this administration and the Project researches has been revised and improved. In the second place, the Project is now

*Presented at the 52nd annual meeting, S.P.E.E., Cincinnati, Ohio, June 22–25, 1944.

*JOURNAL OF ENGINEERING EDUCATION, Volume 34, Number 9, May 1944, pp. 615–625.

completing a series of objective achievement examinations designed to evaluate the student's progress during the pre-specialization phase of the engineering curriculum. These achievement examinations will be in final form and ready for use some time during the first semester of the 1944–1945 school year. The underlying theory of measurement, and the methods and procedures employed in these two test batteries are too involved to be discussed here. We can say, however, that these batteries of examinations are being prepared under the supervision of competent engineering educators and technical advisors. They are designed for a particular purpose, and consequently, it may be expected that they will be distinct improvements over batteries of examinations that have been designed for more general purposes.

Some of you may be disappointed when I inform you, as I must, that the Project is not yet ready to issue anything other than a progress report. The present report cannot in itself be complete, principally because a complete report would be too extensive for any thorough assimilation if presented here. I cannot say today exactly when the Project can make a final, definitive report. I expect, however, that by this time next year, we will have accumulated enough data and research findings so that our results will not be significantly changed by further research, except as conditions change in the future.

My purpose is to discuss three basic considerations in a freshman selection and guidance program: first, to distinguish between a student evaluation program and a measurement program; second, to describe briefly what values may legitimately be expected from the continued use of entrance examination results in a freshman guidance program; and third, to present certain preliminary findings of the Project together with their implications for evaluating the character and qualities of freshman engineering classes.

Measurement and Evaluation

The distinction between student evaluation and the measurement of student abilities is of considerable importance to the college admissions officer and the freshman counsellors. Evaluation, as it is commonly understood, includes all of the procedures for the appraisal of aptitudes, abilities, achievements, personal qualities, and other distinguishing characteristics of the student. Measurement is that portion of evaluation to which precise, quantitative means of appraisal may be applied. Evaluation then is the larger, more inclusive process. It implies measurement but at this time it cannot be effected by measurement alone. In an effective evaluation program there must be, in addition to the measurement or testing program, a systematic use of all the available techniques and procedures for estimating the student's potentialities for engineering study. Evaluation also implies guidance, that is, the effective distribution of students to those particular activities for which they are best suited and in which they can experience the greatest degree of success.

Evaluation techniques can be applied to any aspect of the student's development. In many instances the results of appraising certain student characteristics must necessarily be vague and subjective; with respect to other characteristics they may be very precise. For example, it is not easy to evaluate quantitatively (and hence

on a comparative basis) the student's ambition, prejudices, attitudes, psychological "quirks," and general mental health—any one of which may very seriously affect his adjustment in college. On the other hand, it is relatively easy to measure his educational background, scholastic ability, physical health, economic and social status, and similar characteristics which lend themselves to quantitative appraisal by methods which are now in general use.

To become more practical, let us examine the elements of an effective student evaluation program at the freshman level. Such a program may or may not be selective in character, depending upon institutional policies.

In the first place, one of the most satisfactory devices for evaluating the entering student's educational development and scholastic ability is an integrated battery of entrance examinations. These examinations should meet certain standards and criteria, some of which I have discussed elsewhere.* The dean of the college of engineering, his admissions committee, and the freshman counsellors or mentors will generally find the results of a systematic testing program more helpful than any other single measure of the entering freshman's fitness for engineering study. This applies to large groups of students, provided the college officials understand the possibilities and, more particularly, the limitations of examinations, whether these examinations be subjective or objective in character. It must be recognized, however, that the predictive value of entrance examinations ordinarily decreases as the students progress through the curriculum. After the first year, and many times, after the first semester, institutional grades become more predictive of future success *in the same college* than entrance examination results.

A second method of evaluating freshman quality is the consideration of a student's high school background as revealed in his high school record, the general configuration of his pattern of previous study, and the quality of the school from which he graduated. This means of evaluation has generally proved somewhat less reliable than that obtained from the best type of entrance examination. This is due in part to the fact that it is most difficult to establish definite criteria and standards of secondary education. The records from a certain high school or preparatory school may be very dependable; from a second or a third, the high school record may be of little value because the quality of achievement, curricular offering, and instructional emphasis are unknown quantities. Most colleges of engineering admit students from a very large number of high schools and are able to determine the quality of only a few of them. This explains, in part, why the high school record is not generally a very dependable criterion for admission.

Any effective evaluation program, however, must include estimates of many student characteristics not identified by objective tests or high school records. In some colleges, economic status is all-important. The student with insufficient funds may be very seriously handicapped in certain types of colleges. It is imperative that the college officials ascertain the physical health of the candidate, and in so far as possible, his mental health. It is important, also, to evaluate the student's interest in and attitude toward the engineering profession; to discover

* *Ibid.*, pp. 615–625.

his ambition and goals in life, his social adjustment and outlook on life. Furthermore, it is desirable to ascertain the student's work and recreational habits, the extent of his participation in extracurricular activities, and his leadership qualities.

It is obvious that an effective evaluation program extends far beyond the present possibilities of measurement. It is obvious also that evaluation is a continuous process; that not all of these appraisals can be made before the student enters college or immediately thereafter. Because of these and other factors, elimination from college can never be reduced to zero. If it were, it would only be an indication that many students who could profit from college and perhaps become outstanding engineers are denied the right to be trained. This, as you recognize, is contrary to the democratic principles underlying our educational system.

The Possibilities of Measurement

I

Entrance examinations serve several purposes of which two are of primary importance: first, discovering the adequacy of the student's educational background as compared with other students of the same kind; and second, providing a basis for estimating the strengths, weaknesses, needs, and potentialities of the student. Although these two functions frequently overlap, the character of examinations obtaining such results may differ considerably in character as well as in purpose. With respect to the first function, the entrance examination battery may consist entirely of tests of specific abilities or achievements to the end that students may be placed in general classifications or groups. For example, scores on an English, mathematics, or social science examination may be used to place a student in a course or curriculum so that he may reach a certain minimum level of development demanded by the institution. In the college of engineering, a mathematics test may serve as a basis of determining whether or not a student is prepared to begin a study of analytical geometry or differential calculus. If not, he may be required to take a course in college algebra on a "make-up" basis. The application of such examinations does not necessarily imply that the results of the examination are being used for purposes of estimating the potentialities of the student or predicting his success in general, although many such tests may be useful for this purpose.

As just indicated, the entrance examination may provide a basis for estimating the probable success of a student during a specified period of time. A testing program with this as one of its functions should include a number of tests whose results are as highly related to success in the engineering curriculum as possible. This should be supplemented by other examinations less highly related to student success but which possess diagnostic values. These latter examinations, when properly used and interpreted, serve an important purpose. With our present development of measurement techniques, the predictive value of even the most successful tests is limited. Given the test results for a student and certain other information, it is possible to predict within certain limits the probabilities of success (or failure) of a student in a given situation. If the test performance on these highly predictive tests can be supplemented by the records of performances on other exami-

nations of a diagnostic character, it is frequently possible to improve on this prediction, even though the correlation between scores on the diagnostic tests and success in the engineering curriculum is low.

The *Pre-Engineering Inventory* which has been developed by the Project Committees includes seven tests, three of which are highly predictive in character, namely, *Technical Verbal Ability, Ability to Comprehend Scientific Materials,* and *General Mathematical Ability.* The battery also includes such tests as *General Verbal Ability* and *Understanding of Modern Society* whose results are not in themselves highly related to success in engineering subjects. Scores on the *General Verbal Ability* test are not highly related to the student's success during the first year of engineering education, but students who have very low scores on this test appear to have trouble early in their period of study, primarily because their abilities are "non-verbal" in character. Thus the *General Verbal Ability* test serves as a diagnostic test rather than a test which can be used for general prediction. Test VII, *Understanding of Modern Society,* is included for still another reason. We justify the inclusion of this test on the basis that a student should have acquired, or subsequently acquire, the important political, economic, and social concepts underlying and permeating the society in which he lives. Such tests, therefore, provide the institution with measures of important concomitant accomplishments on the part of entering students.

It is obvious from the most recent report of the *Committee on Engineering Education After the War** that educators are considering the engineering curriculum in a broad sense, emphasizing along with the scientific-technological objective the simultaneous development of the humanistic-social objective as well. Any system of freshman examinations which defeats or ignores this commendable dual purpose is short-sighted in the extreme—it fails to emphasize to freshman students the importance of this objective.

II

It is a well known fact that the typical entrance examination battery measures general intelligence, scholastic aptitude, and educational achievement, generally in unknown amounts. That is, such batteries measure the student's mental equipment, learning power, or achievement in the educational sense. Success in college, whether it be in engineering or other curricula, does not depend entirely upon the student's intellectual equipment. Consequently, many of the failures in the engineering curriculum may be attributed to factors or causes which are not measured by the entrance examination battery. If, on the other hand, the college freshman evaluation program is adequate, many of these factors and causes can be identified and observed in advance. It is decidedly unwise, therefore, to depend upon the entrance examination for all of the information that may be collected concerning the individual student. His mental or physical health, his adjustment to the college environment, his release from the close supervision of his parents, or any one of a number of other conditions may account for his lack of interest or poor showing in college. *The entrance examination cannot be held accountable for qualities not measured by it; it*

* *Ibid.,* pp. 589–614.

cannot be condemned for failing to predict success where factors outside its scope are causal. Its results must be considered for what they are—a fairly consistent and efficient estimate of the student's intellectual equipment.

In the long run there is a higher relationship between "scholastic aptitude" and success in college than any other single factor. Most engineering students are healthy, most have a normal outlook on life and make adjustments fairly easily, most are interested in what they are setting out to do, most of them persist and graduate. If the student is intellectually capable, he generally has better than an "even chance" to graduate. If on the other hand he has to overcome intellectual deficiencies, he is handicapped from the start and sooner or later is called upon to exert greater efforts, relatively speaking, or drop out.

III

The meaning of the term "scholastic aptitude" is of primary importance in the measurement program. Some writers refer to scholastic ability in a general sense, and when the term is used in this manner, it is assumed to be highly related to general intelligence. It is not enough to say that a student has scholastic aptitude unless you further define in an operational sense that he has scholastic aptitude for the study of particular subjects or subject fields, *e.g.*, engineering, art, business. Certain psychologists endorse the view that intelligence is made up of a general factor, "g," and various special factors, "s." Not being a student of psychology in the theoretical sense, I am not prepared to say whether this interpretation is justifiable. I am convinced, however, that intelligence as measured by a general intelligence test is not the best indicator of success in engineering study. I think you will agree with me that general intelligence is not the most dependable basis on which to select engineering students. The men in the A.S.T.P. were selected primarily on the basis of the Army General Classification Test which is a sort of intelligence test. Every man in the A.S.T.P. was significantly above average in intelligence as compared with all men who have gone through army induction centers. Nevertheless, there were thousands of men in the A.S.T.P. who were not properly qualified for engineering study. It cannot be denied that most of the men in the A.S.T.P. had scholastic aptitude in the general sense, but this scholastic aptitude in many instances was not that particular combination of special abilities which fitted the soldier for the study of engineering or other technical subjects.

Had the Army eliminated all those men who had not successfully completed two years of high school mathematics, the quality of the A.S.T.P. trainee would have been materially improved, the attrition decreased, and instruction and achievement in the program generally improved. The Army obviously was operating on the assumption that men are able to succeed in engineering because of superior intelligence, irrespective of the high school pattern of study. There is definite evidence that this assumption was not borne out.

Aptitude for engineering includes, in addition to general intelligence, a pattern of special intelligences or abilities, whichever you may term them. One of the best approaches to measuring this complex ability appears to be the work-sample approach in which there is no attempt to identify the factors or

elements of this complex. After determining the types of work that the student is called upon to do early in his study of science and engineering, we can select work samples which are not too difficult for the average entering student. We can construct examinations testing the student's ability to do these samples of work. The thoroughness, effectiveness, and accuracy with which he works is reflected in his test score. The test score naturally correlates well with what he will later do in the same type of work. This is the approach that we have employed in the *Pre-Engineering Inventory*, and with partial modification, is the approach that has been employed in the achievement examinations. When this approach is employed, measurement cannot be effected instantaneously. In fact, the coöperating colleges are devoting five and one-half hours of time to examining entering students. We have never seriously considered the idea of developing a fifteen or twenty-minute test which would definitely predict whether a freshman student will succeed in engineering. We are more interested in evaluating as many of the different aspects of the student's training and background as possible.

IV

You have heard much of the validity of test batteries, that is, the effectiveness of a test battery for a particular purpose. These validities are generally expressed in terms of correlations between test scores and success in the engineering curriculum—measured either in rankings, course grades, achievement test results, or combinations of these methods of appraising achievement. These validities, which are generally expressed in correlation coefficients such as .55, .65, or .75, embody one of the most important concepts involved in the use of test results for purposes of estimating the student's chances of success or failure in a given activity. These coefficients of validity are a direct measure of the dependence which can be placed in the test results for predicting the student's chances of success.

For purposes of illustration, let us assume that for several years your college has been administering three examinations, that during this time the student population has been a normal one, and that 20 per cent of the students enrolled during that period were eliminated from college because of scholastic failure. Assume also that your admissions committee reports that the correlation coefficient between grade-point average and scores on Test I is .55, on Test II is .65, and on Test III is .75. What will be your interpretations? Clearly Test III is superior to either Test I or Test II, but what gain in predictive power is made possible by this increase in the correlation coefficient? What confidence can you place in the results or rankings on each of these three tests? This is a question which has troubled many who have attempted to interpret the statistical nomenclature of prediction.

Without a freshman evaluation or measurement program of any kind, you would be able to say to each student as he entered that, so far as you know, he has *four chances out of five* to pass the term. This would be the best estimate that you could make in the absence of information about the student other than the fact that he meets the normal entrance requirements of your institution. Yet we know that some students in this entering group do not have one chance out of five to pass the

term. The problem is to identify these students whose failure potential is high.

Under the conditions just stated, the coefficients of test validity .55, .65, and .75 have fairly clear-cut meanings for predicting the entering student's chances of success or failure during the first semester or the period for which the validities of the tests were established. Let us assume that the scores on the tests are expressed in terms of percentile ranks so that we can determine the *decile* standing of the student with respect to the other members of the entering class. That is, we know whether the student ranks in the lowest tenth of his class, the fourth tenth, or the highest tenth as determined by his scores on each of these three tests. With the student's decile standing on the tests, the normal failure rate, and the test validities as our data, we can predict the student's chances of success and failure on the basis of his score on each test. By so doing, we can also obtain an appreciation for the difference in predictive power of tests whose coefficients of validity vary from .55 to .75.

Knowing that this hypothetical college of engineering has a normal failure rate of 20 per cent, we naturally will scrutinize closely the test records of those students in the *lowest* and *second* tenth of test scores, for it is from this 20 per cent that we would expect the largest proportion of failures. The average student in the lowest tenth of the class as ranked by Test I (validity .55) fails the term in 53 per cent of the cases; as ranked by Test II (validity .65), 62 per cent; and as ranked by Test III (validity .75), he fails in 72 per cent of the cases. Clearly there is a definite gain in predicting the student's chances of success on the basis of these three tests. The average student in the second decile is, of course, less apt to fail. As predicted from results on the three tests, the second-decile student can be expected to fail in 37, 41, and 46 per cent of the cases, depending upon the validities of the tests upon which the predictions were based. Table 1 lists the number of students per thousand that normally may be expected to pass a course of study under these conditions.

TABLE 1*

NUMBER OF STUDENTS PER THOUSAND THAT WILL PASS A COURSE OF STUDY AS PREDICTED FROM DECILE STANDING ON ENTRANCE TEST WHEN THE FAILURE RATE IS 20 PER CENT

Decile Standing on Test	Coefficient of Test Validity		
	r_{tg} = .55†	r_{tg} = .65	r_{tg} = .75
Highest Tenth			
X	982	994	999
IX	955	977	993
VIII	927	954	979
VII	896	925	956
VI	862	888	921
V	823	841	871
IV	775	782	798
III	713	702	694
II	627	587	539
I	470	382	277
Lowest Tenth			

* Adapted from a table by Richard P. T. Scott presented in "Statistical Procedures and Their Mathematical Bases," C. C. Peters and W. R. VanVoorhis, McGraw-Hill Book Company, New York, 1940, pp. 508–10. The table is read as follows: The average student in the upper tenth of the class (95th percentile) as determined by a test whose coefficient of validity is .55 normally will pass the term in 982 cases in 1,000; the average student in the lowest tenth of the class (5th percentile) as determined by the same test normally will pass the term in 470 cases in 1,000.

† r_{tg} is the correlation between test scores and course grades or grade-point averages.

It is obvious from this table that the poorest students as identified by these tests have less than an even chance of success, but what of the best students in the class? It is with respect to this group, say the upper one-half of the class and more particularly the upper quarter, that the test results are most predictive. In the highest 10 per cent as ranked by Test I, only 18 out of 1,000 will fail and this is decreased to only 6 and 1 in 1,000 in the cases of Tests II and III, respectively. Thus a student in the upper tenth of the class as identified by any one of these three entrance examinations can be depended upon to pass the first term, unless factors not measured by the tests operate in particular instances.

I have discussed these three validities, .55, .65, and .75, because they have particular significance for the freshman entrance examination program. Most *good* test batteries now in general use in colleges of engineering have a validity of approximately .55. Very few indeed range from .65 to .75 when these validities are correlations between test scores and grade-point averages or pass-and-fail during the first semester. The *Pre-Engineering Inventory* is in the latter group when administered to fairly large groups of students and the elimination rate is equal to or greater than 10 per cent.

Correlations of the magnitude of .55 have considerable limitations for purposes of prediction, yet it is obvious that except for the lower 40 per cent of the students, the prediction is entirely usable. The important generalization as it applies to your measurement program is that it is not possible to say definitely to an applicant that he has no chance whatsoever of succeeding in the college of engineering, however low his test scores may be. This statement may be true in many cases, but it cannot be inferred from test scores alone. I caution you, therefore, that if you are expecting the Project to develop a battery of examinations which will sharply differentiate engineering students from non-engineering students, you will be disappointed; it is not possible, on the basis of test results, to distinguish sharply between those who can become good engineers and those who can never become engineers, and I doubt that this distinction should be attempted, except in extreme and obvious cases. About the best we can expect to obtain from test results ($r_{tg} = .75$) is an estimate that the poorer students in the group will have only about *one chance in four* of succeeding. In that same group, we can be very confident that the students in the upper half of the entering group will succeed in more than 97 per cent of the cases (1½ per cent failure), again assuming a total failure of 20 per cent.

In defense of the entrance test, I wish to point out that this lack of precision is not alone a deficiency of tests in general. One of the principal reasons why test validities do not ordinarily exceed .70 is the lack of reliability or dependableness in course grades with which test scores have been so frequently correlated. Unless we are able to obtain more dependable indices of the student's success in college, either through ranking by instructors, achievement examinations, combined judgments, or other techniques, it will be extremely difficult to increase the validity of test batteries to as much as .75. When these more dependable criteria are obtainable, we can place greater dependence on entrance examination results, not because of any improvement in the test

batteries, but because the estimates of achievement which they are intended to predict have become more dependable and, we hope, more accurate.

Some Evidence of the Validity of the Pre-Engineering Inventory

Let us now consider briefly the results of two Project studies which illustrate some of the principles previously discussed. The first study was concerned with a general college population in a large university and the second was a study of a large A.S.T.P. group in a second university.

I

At University A, the *Pre-Engineering Inventory* was administered to 1,175 freshman students entering in the fall of 1943. In this class there were 428 engineering students, 167 science students, 162 liberal arts students, and 418 business or commercial students. Only three *Pre-Engineering Inventory* tests were studied: *General Verbal Ability, Technical Verbal Ability,* and *Comprehension of Scientific Materials.* University A also administered a systematic test battery of its own which included the American Council on Education Psychological Examination, the most widely used test of general scholastic ability at the freshman level, and the Coöperative General Achievement Tests.

The testing program at University A provided an opportunity for making an interesting comparison between three types of tests for selecting pre-engineering students. The American Council on Education Psychological Examination is commonly recognized as a general scholastic ability test. It is widely given as a college entrance examination to students entering various curricula. It affords, consequently, a basis for making comparisons among curricular groups. This measure of comparability is very useful in follow-up studies of the effectiveness of selection tests. The Cooperative General Achievement Tests I, II, and III (Social Science, Natural Science, and Mathematics) were constructed to measure achievement in their respective fields as taught in grades 9 through 12. These tests have also been used in many instances as college entrance examinations, further increasing the range of ability to which they are assumed to apply. The *Pre-Engineering Inventory,* on the other hand, was specifically designed to test those abilities which are of particular importance in the study of engineering and was carefully adjusted to the abilities of engineering students, rather than freshman college students in general.

The test results for the four curriculum groups are summarized in Tables 2, 3, and 4. For purposes of illustrating the point concerning general versus specific scholastic aptitudes made earlier, consider first the mean scores and standard deviations of scores for the four groups on the A.C.E. Psychological Examination presented in Table 2. Judging from these results, it would be reasonable to assume (1) that the Engineering, Science, and Liberal Arts groups have approximately the same "scholastic aptitude" and (2) whatever differences exist among these three groups can be attributed primarily to differences in quantitative ability ("Q" score) as measured by the A.C.E. Psychological Examination. The Business group, in this instance, is systematically lower in test performance than the other

three groups and this fact is observable in the results of all other tests administered. Further evidence that the Engineering, Science, and Liberal Arts groups do not differ significantly in linguistic or verbal ability is found in the results for *Pre-Engineering Inventory* Test I presented in Table 4.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF SCORES ON THE AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL TEST FOR FOUR CURRICULAR GROUPS AT UNIVERSITY A

Group	N	"L"*		"Q"†		Total	
		M	S.D.	M	S.D.	M	S.D.
Engineering	428	70.38	13.91	47.18	8.61	117.56	19.31
Science	167	70.67	14.01	45.33	9.02	116.00	19.85
Liberal Arts	162	71.73	14.42	42.35	10.23	114.08	21.38
Business	418	63.43	13.13	39.91	9.74	103.34	20.07

* Linguistic Section. † Quantitative Section.

TABLE 3

MEANS AND STANDARD DEVIATIONS OF SCORES ON THE COÖPERATIVE GENERAL ACHIEVEMENT TEST FOR FOUR CURRICULAR GROUPS AT UNIVERSITY A

Group	N	I*		II†		III‡	
		M	S.D.	M	S.D.	M	S.D.
Engineering	428	73.37	9.88	68.81	6.77	69.78	6.68
Science	167	72.57	10.22	67.32	6.52	67.47	6.61
Liberal Arts	162	71.79	10.38	62.57	6.48	63.55	7.25
Business	418	65.77	9.36	58.28	5.71	59.88	6.44

* A Test of General Proficiency in the Field of Social Studies.
† A Test of General Proficiency in the Field of Natural Sciences.
‡ A Test of General Proficiency in the Field of Mathematics.

TABLE 4

MEANS AND STANDARD DEVIATIONS OF SCORES ON THE PRE-ENGINEERING INVENTORY TESTS FOR FOUR GROUPS AT UNIVERSITY A

Group	N	I*		II†		III‡	
		M	S.D.	M	S.D.	M	S.D.
Engineering	428	39.46	16.22	47.89	16.29	47.97	15.31
Science	167	41.43	16.02	43.14	15.48	42.96	15.14
Liberal Arts	162	42.94	15.91	29.54	16.93	31.75	16.16
Business	418	33.20	15.46	19.00	11.47	24.10	12.84

* A Test of General Verbal Ability.
† A Test of Technical Verbal Ability.
‡ A Test of Ability to Comprehend Scientific Principles.

Distributions of scores for the four groups provide us with information not easily deduced from a consideration of the mean scores and the standard deviations of scores. The distributions of scores on the "L" section of the A.C.E. and the *Pre-Engineering Inventory* test are shown in Figs. 1 and 2. Drawn to the same scale, the distributions of scores in these two figures show marked similarity. This is as it should be since these two tests are intended to measure the same ability.

It would be impossible, however, to select engineering students on the basis of an examination which does not systematically penalize the student who is not particularly well equipped for engineering study. In other words, the distribution of scores for a group of engineering students should be systematically higher than the scores on the same test for a group of liberal arts

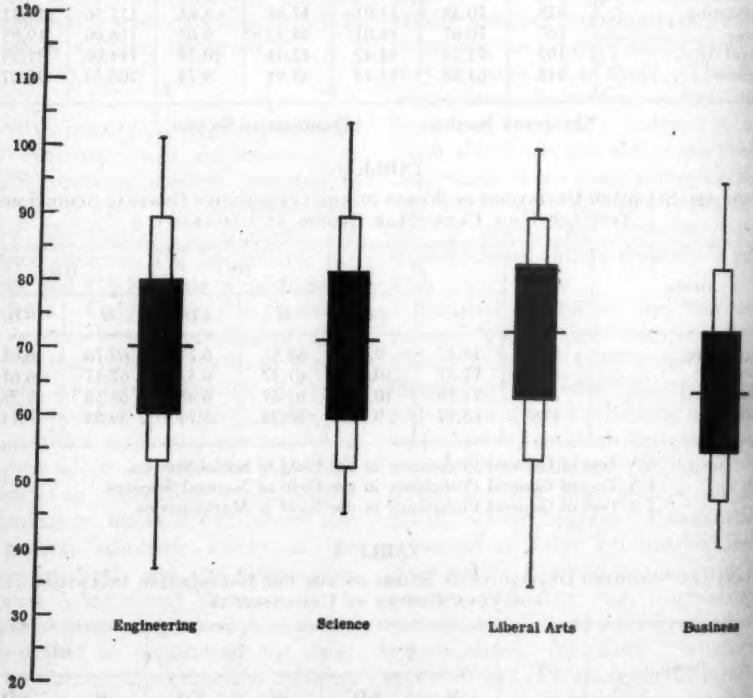

FIG. 1. Distributions of "L" scores (linguistic section) of the American Council Psychological Examination at University A.*

* The horizontal line near the center of each of the four figures represents the mean score for the group of students. The middle 50 per cent of the scores fall between the top and bottom of the black rectangle; all except the highest and the lowest 10 per cent of the scores fall between the top of the upper and the bottom of the lower white rectangle; and all except the highest and the lowest 1 per cent, between the extreme upper and lower ends of each figure.

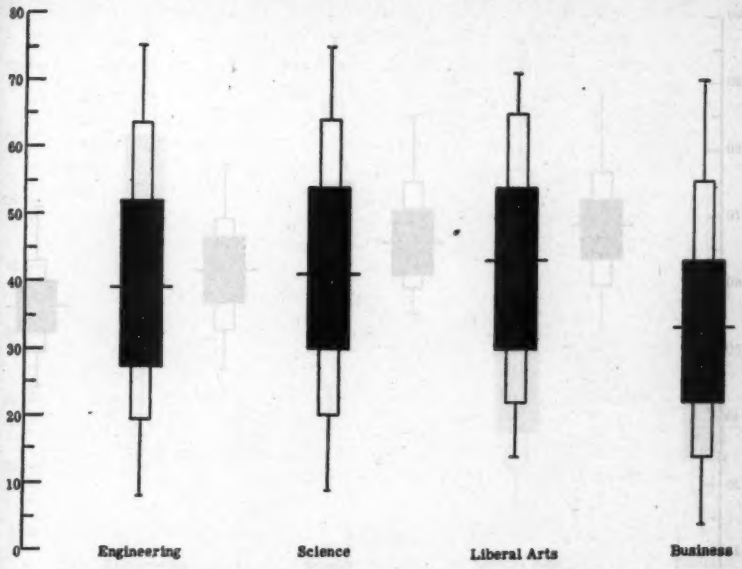

FIG. 2. Distributions of scores on the Pre-Engineering Inventory Test I—General Verbal Ability, at University A.

students, assuming, of course, that the test measures a specific ability which is known or assumed to be necessary for engineering study and not of a crucial nature as far as liberal arts students are concerned. General verbal ability is unquestionably a common denominator in general scholastic ability, but selection for specific curricula cannot be effected on the basis of common denominators.

The problem then is to construct a test which will "pull out" the engineering students from the general population of college freshmen. It is possible ordinarily to construct a test in mathematics and high school science which will make this distinction, but the difficulty of such tests must be very carefully adjusted, or the differences will be hidden in the test results. Actually, in some cases, test results may be decidedly misleading since groups can be made to appear quite similar in ability although great differences exist.

There is some evidence, in this case, that the quantitative section ("Q" score) of the A.C.E. Psychological Examination permits the Engineering Group to reveal their superior ability in mathematics (see Table 2). This difference, however, is somewhat obscured by the small differences in the total score. The heavy weighting of the linguistic section of this test tends to overweight the quantitative section for purposes of selecting engineering students from a general freshman population.

The necessity for a test carefully adjusted in terms of difficulty is demonstrated in the results for the Coöperative Natural Science Test and Tests II and III of the *Pre-Engineering In-*

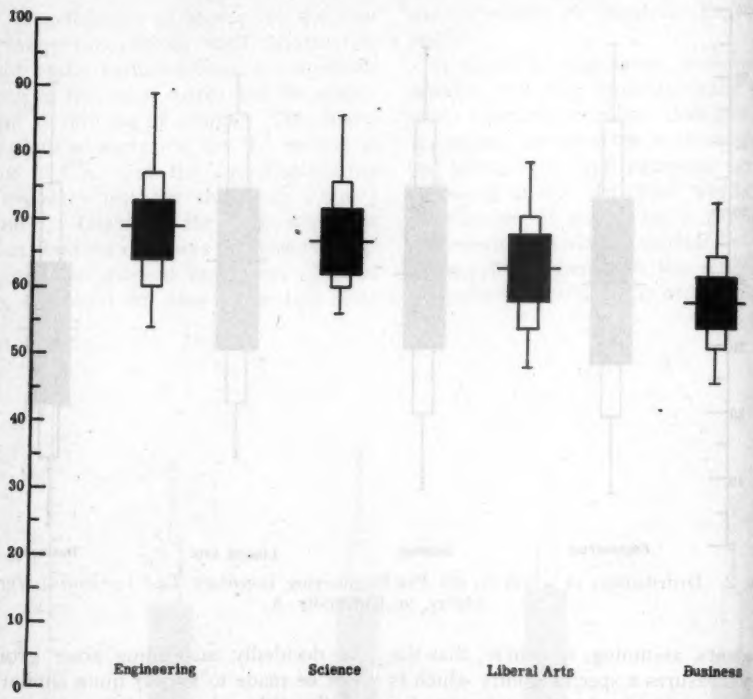

FIG. 3. Distributions of scores on the Coöperative General Achievement Test II (Science) at University A.

ventory. The principal difference between these science tests is the range of difficulty of the test situations and the sampling of the content presented, yet the distributions of scores are markedly different.

Consider first the uniformity of the mean scores on Test II as shown in Table 3. A small standard deviation (S.D.) indicates that the scores are not widely distributed. Figure 3 indicates also that there were very few scores below 50 in any of the four curricular groups. This score is the intended national mean for eleventh grade students. The effective range of the Coöperative Natural Science Test is, as it pertains to freshman groups, little more than one-half of the total test situations. All students answer at least one-half of the questions correctly and, consequently, discrimination can be effected in only half of the possible range of scores. The Coöperative Natural Science Test is either too steeply graduated in difficulty at the upper end of the scale or there is not sufficient "ceiling" to the materials presented to discriminate effectively within groups of engineering students.

The *Pre-Engineering Inventory* tests maintain, of course, the same order of means but increase the differences between them. The greatest difference

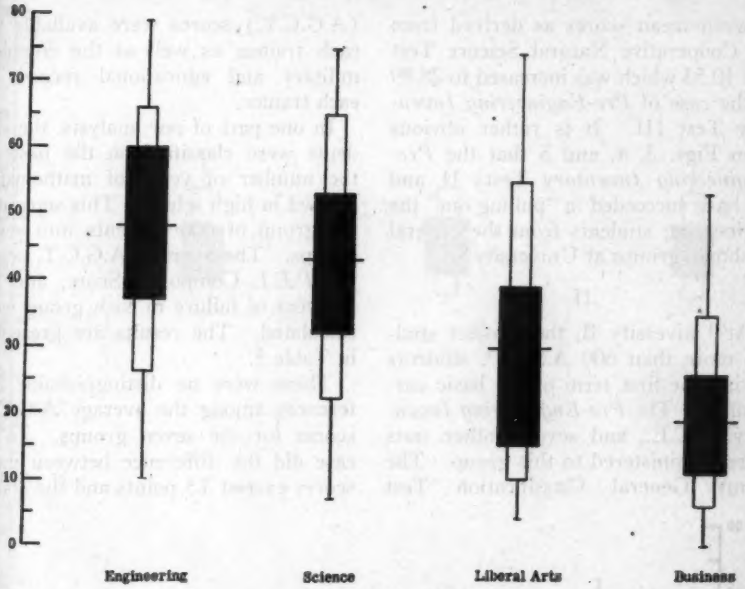

FIG. 4. Distributions of scores on the Pre-Engineering Inventory Test II—Technical Verbal Ability, at University A.

TABLE 5

RELATIONSHIP OF TEST SCORES AND NUMBER OF YEARS OF HIGH SCHOOL MATHEMATICS University B Group (N = 606)*

Years of Study	N	A.G.C.T.		P.E.I.—Composite Score		Students Passing Term			
		M	σ	M	σ	N	%	Grade†	
								M	σ
0	50	123.18	7.44	83.68	26.46	15	30	1.36	.61
1	37	125.86	7.21	85.49	19.07	31	84	1.30	.56
1½	19	123.89	9.67	93.37	21.34	16	84	1.62	.45
2	133	125.95	7.76	100.71	24.52	121	91	1.69	.65
2½	155	125.74	7.47	108.39	30.44	138	89	1.88	.79
3	130	126.32	7.70	118.83	31.16	127	98	2.06	.70
3½	82	125.40	7.65	126.12	29.36	80	98	2.17	.73
Total	606	125.60	7.72	107.44	30.91	528	87	1.86	.74

* Of this number, 52 students were separated from the program before the end of the term for scholastic reasons; 23 students failed and were separated from the program at the end of the term; 3 students were required to repeat Term I.

† A = 4, B = 3, C = 2, D = 1, and E or Fd. = 0.

between mean scores as derived from the Coöperative Natural Science Test was 10.53 which was increased to 28.89 in the case of *Pre-Engineering Inventory* Test III. It is rather obvious from Figs. 3, 4, and 5 that the *Pre-Engineering Inventory* Tests II and III have succeeded in "pulling out" the engineering students from the general freshman groups at University A.

II

At University B, the Project studied more than 600 A.S.T.P. students during the first term of the basic curriculum. The *Pre-Engineering Inventory,* A.C.E., and several other tests were administered to this group. The Army General Classification Test (A.G.C.T.) scores were available for each trainee as well as the complete military and educational records of each trainee.

In one part of our analysis, the students were classified on the basis of the number of years of mathematics studied in high school. This separated the group of 606 students into seven groups. The average A.G.C.T. score, the *P.E.I.* Composite Score, and the per cent of failure in each group were calculated. The results are presented in Table 5.

There were no distinguishable differences among the average A.G.C.T. scores for the seven groups. In no case did the difference between mean scores exceed 3.5 points and the stand-

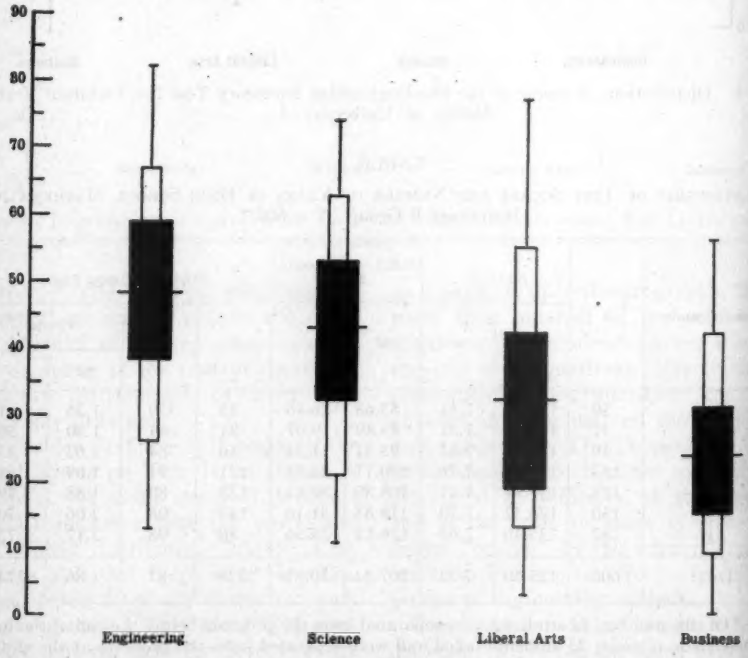

FIG. 5. Distributions of scores on the Pre-Engineering Inventory Test III—Ability to Comprehend Scientific Materials, at University A.

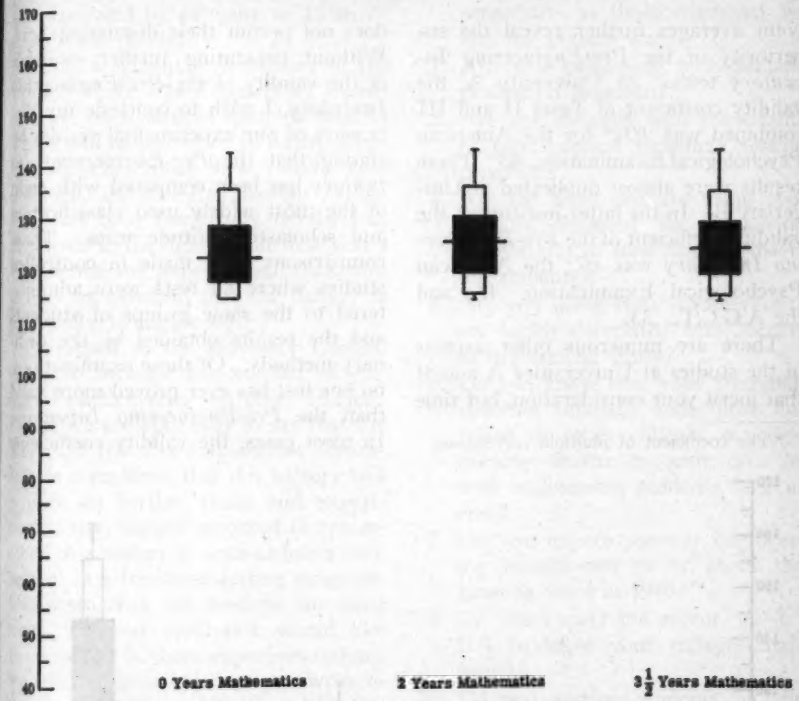

FIG. 6. Distributions of scores on the Army General Classification Test for three groups of A.S.T.P. trainees at University B.

ard deviations were all approximately 7.5. The mean composite scores on the *Pre-Engineering Inventory*, however, indicated that the groups were markedly different. The students having had no formal mathematics in high school received an average score of 83.68 while those who had three and one-half years of high school mathematics received an average score of 126.12.

The distributions of scores also differed markedly. It is evident from Figs. 4 and 5, again drawn to the same scale, that test results can obscure differences that are known to exist between groups of students. It is interesting to note also that the failure rate in the seven groups declined in direct ratio to the number of years spent in the study of high school mathematics. The failure rate for those students who had not had formal mathematics in high school was 35 times greater than that of the group which had had three and one-half years of high school mathematics. Here again is direct evidence of the fact that a general scholastic ability test does not provide the most meaningful estimate of the freshman student's ability to succeed in the college of engineering.

In Universities A and B, correlations between test scores and grade-

point averages further reveal the superiority of the *Pre-Engineering Inventory* tests. At University A, the validity coefficient of Tests II and III combined was .69;* for the American Psychological Examination, .43. These results were almost duplicated at University B. In the latter institution, the validity coefficient of the *Pre-Engineering Inventory* was .67; the American Psychological Examination, .47; and the A.G.C.T., .33.

There are numerous other aspects of the studies at Universities A and B that merit your consideration, but time does not permit their discussion here. Without presenting further evidence of the validity of the *Pre-Engineering Inventory,* I wish to conclude my discussion of our experimental results by stating that the *Pre-Engineering Inventory* has been compared with eight of the most widely used classification and scholastic aptitude tests. These comparisons were made in controlled studies where all tests were administered to the same groups of students and the results obtained by the ordinary methods. Of these examinations, no one test has ever proved more valid than the *Pre-Engineering Inventory.* In most cases, the validity coefficients

* The coefficient of multiple correlation.

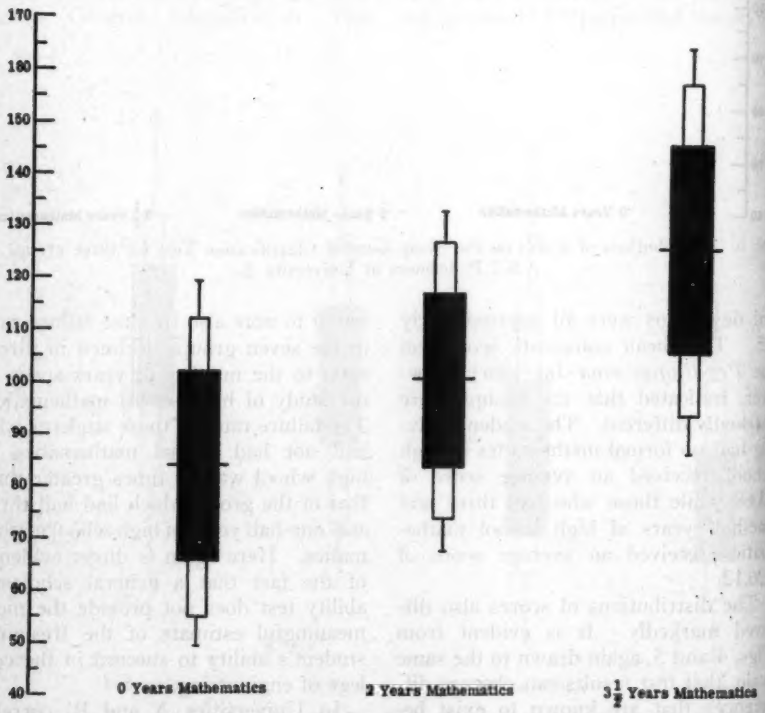

FIG. 7. Distributions of composite scores on the Pre-Engineering Inventory for three groups of A.S.T.P. trainees at University B.

are separated by as many as 15 to 20 correlation points.

These fragmentary evidences of the validity of the *Pre-Engineering Inventory* are only parts of complete studies which will be presented in future progress reports. Since these results were obtained, the *Pre-Engineering Inventory* has been completely overhauled, improved in the light of our first year's experience and experimental data, and it may be assumed that the battery is materially strengthened.

On April 3, the Advisory Council voted to increase the number of colleges participating in the Project. While we are not ready to say that the work on the *Pre-Engineering Inventory* is completed, that this battery will require no further study and experimental use, we are prepared to recommend this battery of tests as being very helpful in a freshman testing program. Our researches will continue for some time. If your institution would like to coöperate in these experimentations, we will be pleased to have you write to the Project Office (437 West 59th St., New York 19, N. Y.) for information relative to participation in the Project.

Implications

In conclusion, I should like to propose ten questions which have implications for the freshman measurement program in colleges of engineering. These are questions with which you will be concerned in the immediate future and, more particularly, in the postwar period.

1. Do you expect to follow the same student selection and guidance procedures as those employed before the present war?
2. Are you employing a systematic evaluation program?
3. Are you satisfied with the results of your present freshman testing program?
4. Are the tests you are using specifically designed for measuring the abilities of freshman engineering students?
5. Are you using tests whose results are highly correlated with success in engineering study?
6. Do you know how your freshman students compare with those enrolled in other colleges of engineering similar to your own or with engineering students in general?
7. Do you expect postwar engineering enrollments to be about the same as those in 1940?
8. Do you expect the recent "G.–I." Bill to leave your college unaffected?
9. Do you section students on the ability basis for instructional and remedial purposes?
10. Are you following a *laissez faire* policy of student elimination?

If you can truthfully answer all of these questions in the affirmative, then you have solved or are not attacking many of the problems of student evaluation; if some of these questions must be answered in the negative, then the Measurement and Guidance Project in Engineering Education may have implications for your postwar policies of student selection and guidance.

Discovery of Engineering Talent*

By R. L. SACKETT

Chairman, Committee on Selection

This Society has been interested in the development of mental tests of general scholastic ability and of aptitudes. The early intelligence tests showed degrees of mental capacity but did little to measure preparation for education in general or in particular.

Tests in English, mathematics, science and numerous other subjects were prepared through the efforts of the American Council on Education. These and the Scholastic Aptitude Test were tried out by various institutions but the results were not sufficiently predictive of success in academic education to satisfy hopes which had been raised too high. There was no general movement to adopt particular tests either for admission or for guidance. Experimentation went on.

Early in the history of Engineers' Council for Professional Development, the Committee on Student Selection and Guidance, with Dean Barker of the Society for the Promotion of Engineering Education, conferred with Dr. Ben Wood of Columbia University. The purpose was to discover selective tests of ability and aptitude for prospective engineering students. The Coöperative Test Service of which Dr. Wood was head had had no experience in that field. The use of English, science, mathematics and other tests was considered. It was finally decided to give the coöperative tests in English and mathematics to 1,738 entering engineering students in eight coöperating institutions in 1934 and again to the classes entering in 1935.

At the end of one year the coefficients of correlation of the math. score with the average grade in all subjects taken varied from $r = 0.440$ to 0.645, the average being 0.554.

The correlation of the English test score with the same average for all grades for the year varied from $r = 0.252$ to 0.580, the average being 0.402.

Charts were prepared for each participating institution which gave a considerable amount of information concerning the grades of each student through three years of college experience with causes for withdrawal or failure when it occurred. The scores in the math. test were given on one chart and the scores in English on another with grade distribution. See E.C.P.D. reports for 1935 and 1936.

From 1937 to 1940 the subject of guidance and the need for selective tests were emphasized. Guidance procedure had been definitely improved by better informed high school counselors and by the aid of committees of engineers.

The increasing number of those being admitted to engineering in the twenties and the percentage of those

* Presented at the 52nd annual meeting, S.P.E.E., Cincinnati, Ohio, June 22–25, 1944.

who failed to obtain a diploma was responsible for that portion of the Investigation of Engineering Education which was concerned with the admission of students and the causes of failure or withdrawal. The information obtained in the Investigation made it clear that boys were admitted to engineering who did not have the interests and abilities necessary to success in technical studies. They had not been well-informed or advised. They had not been led to consider the essentials required to achieve a healthy measure of growth. They withdrew because they were ill-prepared, lacked sustained will-power, ability to concentrate, were ill due to overload on the below average student, or they needed to earn too much of their expenses.

Their grades were below average because admission to engineering departments depended mainly on high school grades in general and did not evaluate aptitude for mathematics, science, visual geometry and engineering interests.

The report of the S.P.E.E. Committee on Selection made at the San Francisco convention in 1940 gave a large amount of information on the wide variation in admission requirements and on the extensive interest in various types of tests given for the purpose of demonstrating general scholastic preparation or specific aptitudes and knowledge. Some tests were used for admission, others for counsel, orientation, or placement. There was no agreement on the purposes which tests should serve or the specific tool to be used. See JOURNAL OF ENGINEERING EDUCATION, October 1940.

THE YALE UNIVERSITY TESTS

In the search for selective tests which would expose arts, science and engineering aptitudes and thus help in guidance, the subject was discussed with A. B. Crawford, head of the Department of Personnel Study, at Yale University.

For some years he had given a battery of tests designed to show the general scholastic field for which an entering or first year student was best equipped.

Through the efforts and interest of President A. R. Cullimore, of Newark College of Engineering, Professor R. S. Bartlett was obtained as a member of the faculty. He had been a graduate student under Dr. Crawford and understood the objectives and procedure in administering the tests. They were revised in view of experience and the battery was given to about two thousand entering freshman engineering students in six institutions. The scores were obtained and at the end of the first year the average grades in all subjects were collected and the correlation worked up. There was definite evidence corroborating previous experience, that the tests did show significant differences between students adapted better to arts or to science or engineering. It also showed that some were equally prepared for any one of the three areas of study, and others who were poorly prepared to attain mastery in any field.

These latter facts were also important but our interest was to discover those who had a definite flair for engineering rather than for another field.

This study was carried for two years with two entering classes and the results were corroborative.

In addition Dr. Bartlett gave a modified battery of the same tests to 1,000 junior and senior high school students in New Jersey in order to study the effectiveness of such tests in suggesting the line of electives which the high

school students should follow in their high school studies.

So far as these students entered engineering schools (particularly Newark College of Engineering) the correlations with their college grades indicated the same general results though the number of students under control was relatively small.

The two reports prepared by Dr. Bartlett received widespread attention by engineering teachers. They were printed in the JOURNAL OF ENGINEERING EDUCATION for November 1941 and March 1943.

The battery was composed of the following tests:

1. Verbal comprehension
2. Artificial language
3. Verbal reasoning
4. Quantitative reasoning
5. Mathematical aptitude
6. Spatial visualization
7. Mechanical aptitude

The results justified the belief that certain aptitudes could be measured. There was evidence that math., science, spatial visualizing ability and mechanical aptitude were important factors in differentiating prospective engineers. More information was necessary to demonstrate the weight to be given any test and to establish its general validity by giving achievement tests or by some other method which will explain differences in the results obtained under different conditions.

After the two year study which supported the opinion of Dr. Crawford concerning the significance of the Yale tests, Dr. Bartlett accepted the headmastership of Gunnery School, at Washington, Connecticut.

It was important that this line of study be carried further. Appeal was made to the Carnegie Foundation for the Advancement of Teaching through Dr. R. E. Doherty, then Chairman of E.C.P.D., President A. R. Cullimore, chairman of the Committee on Student Selection and Guidance, E.C.P.D., and the writer. Interest was taken in the subject by Dr. W. A. Jessup, President of The Carnegie Corporation and of The Carnegie Foundation, by Dr. W. S. Learned, and Dr. K. W. Vaughn, the last of whom was later designated Director of the Measurement and Guidance Project in Engineering Education. After due consideration, a tri-party agreement between the Carnegie Foundation S.P.E.E. and E.C.P.D. was arranged and approved by the parties concerned.

It provides for a continuation of the test method but with two changes in procedure.

First, the preëngineering inventory-battery of tests was changed to include:

1. General verbal ability (general vocabulary)
2. Technical verbal ability (technical vocabulary)
3. Ability to comprehend and interpret scientific materials
4. Ability to do quantitative thinking (mathematics)
5. Ability to comprehend mechanical principles and applications
6. Spatial visualizing ability

The second change in program is the decision to employ achievement tests to be given probably in the second year as one base for computing correlations of test scores with the results of the first year of study.

The average grades of all students as obtained by the usual methods of each institution will also be used.

This procedure will serve as a base for the study of achievement tests and institutional grading. A very careful

and detailed study of each preëngineering inventory test, the achievement tests, and college grades is desirable to establish their validity.

There should be no illusions. The program is an extensive survey of the effectiveness of tests by which to select engineering students and the basis upon which to measure the reliability of such selection. By virtue of the complexity of human abilities, the importance of personality and character, there is much territory not yet cultivated but it is believed that a gradual approach is being made by sound educational engineering methods.

Comprehensive Examinations*

By R. H. FRAZIER
Massachusetts Institute of Technology

In discussion at the Conference on Tests and Comprehensive Examinations at the annual meeting of the Society seven years ago at Cambridge † I remarked that owing to the lack of precise terminology a comprehensive examination can be anything any of us say that it is. I was led to that remark by the fact that in none of the half dozen excellent papers presented at the conference was the word "test" used; all authors dealt with "comprehensive examinations," but took the meaning of the term for granted, and no two authors meant the same thing. In that same discussion I suggested that the Committee should consider for its next step an endeavor to codify the various brands of examination called *comprehensive* in order that a mutually understandable terminology might be available. Examination terminology like some of the terminology of economics and of law, for example, gets into difficulties owing to the fact that many every-day words are used in technical or special senses which for examinations may have only vague meanings.

When I became chairman of the Committee on Comprehensive Examinations several years ago (the "Tests" had been dropped from the committee title for reasons that I do not know) we decided that our first objective should be an attempt to find out what we were talking about. My brief discussion of comprehensive examinations here can therefore serve also as a report to the Society on that activity of the Committee.

At the conference of the Committee at the Ann Arbor meeting three years ago a rather extensive codification of comprehensive examination terminology was presented that contained definitions, charts, tables, and specifications. This work was printed in the November 1941 JOURNAL.* Reading to you from the reprint would sound more or less like reading the dictionary, so I content myself by merely calling to your attention the fact that the work has been done and is available in print, and by endeavoring to explain to you the general principles that guided the work and resulted in the rather broad concept of comprehensive examination that it presents. Probably I should qualify my following remarks by saying that while I believe that the members of the Committee are in general accord on philosophy of this work, they have not had opportunity to review my

* Presented at the 52nd annual meeting, S.P.E.E., Cincinnati, Ohio, June 22–25, 1944.

† JOURNAL OF ENGINEERING EDUCATION, v. 28, pp. 368–369.

* On "Terminology and Specifications for Comprehensive Examinations in Engineering," JOURNAL OF ENGINEERING EDUCATION, v. 32 (1941), pp. 239–246.

current interpretation of it. The Committee of course cannot claim status of Official Standard for the work, because it has had no official adoption by any authorizing body, whatever such body should be. It was put forth as a first trial for purpose of criticism and refinement. Owing to war conditions with the activities of the Committee largely suspended during the past few years, the work has received little criticism or other consideration.

In considering the miscellaneous kinds of examination that have gone under the name *comprehensive,* the different objectives, the differences in scope, the different levels at which the examinations are placed, and the differences in details of administration, the Committee might have taken either of two views: first, that all these concepts of comprehensive examination cannot be right, and that hence a rather narrow definition must be formed limiting the concept of comprehensive examination to a very special device; or second, that a broad definition should be formulated based on general principles common to many of the brands in existence, leaving room for variation of details. The Committee has taken the second of these views and has held that whatever the details of construction and administration may be, in order to earn the title *comprehensive,* the examination should be built on certain general principles: (1) the examination should encourage correlation of subject matter of the curriculum and perchance extracurricular experiences of the examinees, (2) the examinations should eliminate the official forgetting points commonly established by the usual term examinations or quizzes in individual courses or in fragments of them, and (3) the examination should acquire comprehensiveness by placing emphasis upon *comprehension* rather than through mere enormity of scope or by effort to include examples of every aspect of the ground covered.

When based on these principles, we say that a comprehensive examination may be of the objective or nonobjective (subjective) *type,* it may be given at the entrance, sophomore, senior, graduate, professional or some other *level,* it may include a single subject such as mathematics (up to the level of the examination), or an entire curriculum such as electrical engineering in its *scope,* it may be oral, written, or laboratory in *style,* and may have several *aims* and *uses;* it may use outside or inside examiners, may or may not permit the use of books or other references, and may have any desired *duration.* The examination may of course contain both objective and subjective *parts,* oral and written parts, open-book and closed-book parts, and so on. In what I have just said, I have more or less given by inference definitions of some of the terms established by our Committee. We say that when the type, level, scope, style, parts, aims, uses, examiners, reference conditions, and durations have been specified, the *pattern* of the examination has been set. We have a chart in which by making check marks, inserting numbers, or encircling letters this pattern can be quickly indicated.

Establishing the pattern for the examination fixes the broad outline into which its *elements* must be filled. We call each *question, problem,* or *project* an element of the examination, and we call each assemblage of elements of one kind a *part* of the examination. Establishing the pattern requires a breadth of view and a feeling for what he is trying to do that is not very well de-

veloped either among engineering educators or practicing engineers owing to lack of experience with comprehensive examinations as herein visualized. The detailed work of developing the various parts of the examination requires skills also inadequately developed owing to lack of experience. The various techniques that are involved cannot be adequately discussed here within the time permitted, so I shall limit myself to one aspect of the situation.

Whereas a well rounded comprehensive examination can accommodate a variety of parts, in my opinion the principal part should consist of projects, or problems each of which in itself is comprehensive, and may demand some exercise of judgment in formulation and solution. The basic principles set down for comprehensive examinations cannot be met merely by saving all the usual quizzes and term examinations until the end of the year or the end of the curriculum and putting them on a pile. The problems must be designed so as to compel the use of the interrelations of several subjects just as is often encountered in practice. The professorial approach to the construction of such problems often is too synthetic. The professor sets out to bring in certain material or bust, and produces a most artificial concoction. The practicing engineer usually has more ample sources than the professor from which to draw his material, but often fails to strip the problems of enough of the secondary details to make solution possible in a reasonable time. The best procedure seems to be to obtain a first draft from a practicing engineer and to subject it to some professorial editing, which preserves the interest inherent in the reality of the problem but reduces it to practical dimensions for the examination.

Several reasons can be given for the slow development of comprehensive examination technique. Among them are limitations of time and expense, and general inertia. Not the least of them is the traditional view shared by student and instructor that an examination is merely a necessary evil that puts a number beside the student's name and decides his academic fate. When examinations pass from the status of mere superposed hurdles to vitally useful components in the educational process, both student and instructor view them with interest and real enthusiasm, as has been amply demonstrated by experience with comprehensive examinations of the kind characterized by this discussion, which provide a most favorable influence as built-in members of the educational structure.

In the brief time at my disposal I have been unable to go into many details but have endeavored to explain the following views about comprehensive examinations:

(1) A comprehensive examination is not a narrowly definable kind of examination to which one may point and say "this is it"; rather it is definable in terms of basic principles with allowance of considerable latitude for details of pattern.

(2) A need exists for definite examination terminology. The Committee on Comprehensive Examinations has made a start toward meeting this need. Persons interested in the details are referred to the results of the Committee's work available here in reprint form, or in the November 1941 JOURNAL, and to other references given there.

Selection and Guidance Aspects of Coöperative Engineering Education*

By R. C. GOWDY

Dean, University of Cincinnati

There are strong indications that the "coöperative plan" will be adopted by many educational institutions of various kinds and at all levels of training as soon as a supply of students is again available. If this expansion is made merely by changing the calendar to permit part-time work, the benefits will be purely accidental, but if the educational possibilities of the plan are carefully exploited many advantages may be gained for the student, for industry, and for the colleges.

It may therefore be appropriate at this time to discuss briefly the functioning of the coöperative plan in the selection and guidance of students in engineering. If I express only limited regret and apology for the absence of quantitative analysis, perhaps I may find some, at least, who believe that subjective evaluations cannot be entirely replaced by arithmetic where human values are concerned, and others who will feel a passive gratitude in having been spared another questionnaire.

The coöperative plan of technical training, was, as you know, placed on an operating basis at the University of Cincinnati, in 1906, by the late Dean Herman Schneider. Reduced to its simplest terms this plan contemplates a parallel training in theory and in practice. Students spend approximately equal time in industrial employment and in college training. Stripped of operational mechanisms that is all there is to it, but as a philosophy of education it is, as Charles F. Kettering has summarized in concentrated phrase, a method of "lap-welding" rather than "butt-welding" technical training and professional activity.

Since the coöperative plan includes standard academic practice dovetailed —or "lap-welded"—with industrial experience, it is obvious that all of the methods and procedures of selection and guidance which are applied in regular full-time technical programs may be used without change or modification in coöperative colleges. It will, therefore, be the purpose of this paper to indicate points of difference, rather than similarity, in the functions of selection and guidance as they appear in the operation of the coöperative plan contrasted to the conventional method of training.

It might as well be admitted without subterfuge, excuse, or alibi, that all of us have been fairly equally unsuccessful in solving the problem of selection. We all have high mortality in the freshman year, and have come to make a virtue out of this vice by

*Presented at the 52nd annual meeting, S.P.E.E., Cincinnati, Ohio, June 22–25, 1944.

throwing over it the cloak of "high standards." Human beings, changeable as they are at the age of entrance to college, may not be accurately measurable in immediate or potential ability, but no administrator can view without self-accusation the long lists of "withdrawn," "suspended," and "dismissed" students, compared to the small files of graduates.

The coöperative plan does not solve the problem of selection, but it does introduce an additional grid in the screening process. It will probably be accepted that the proper attitude of a student towards his work is a necessary, if not a sufficient, condition for success, and that a high I.Q. is valuable only when combined with determination. Perhaps the educational psychologists may eventually devise tests which will give reliable evaluation of motivation, but, so long as there is a traditional glamour to college life and a feeling among parents that a college education must be given to their offspring to achieve or maintain family prestige, many will come to academic halls who have no right nor purpose in being there. The coöperative plan does not solve this problem, but it greatly reduces it. The prospect of callouses, broken nails, and sore muscles, eliminates to a large degree the students who do not have serious purpose. It is not necessary for the admission authorities to do anything to enforce this selection, it is automatic, at least in colleges in which only coöperative programs are offered. The converse of this proposition is, of course, not true, that students who prefer the conventional programs are, ipso facto, dilettante, nor does it follow that cooperative students are "grinds" and do not take an active part in extra-curricular activities, for, in spite of heavy schedules and work-period interruptions, it is the general experience that these students do find time for normal development in student activities.

There is also a factor of false selection operative in full-time colleges which, if not absent in coöperative institutions, is rendered less determinative, and that is the financial qualification. It has generally been the practice to treat the income from industrial work as a fortunate by-product of the practical experience. This is a necessary attitude for the college to take, since, otherwise, the student is likely to insist on the best-paying job, whether or not it provides the best training. But it is nevertheless, a fact, that the earnings of coöperative students have provided many of them an opportunity for professional training which they would not otherwise have been able to obtain.

A third result of the coöperative plan serves partly as belated selection and partly as guidance. There are many paths by which students reach the doors of an engineering college. Some have followed roads which have been direct and clearly marked by well recognized aptitudes and preferences. Others come by devious routes and a few arrive by chance or by misdirection, not infrequently given by determined parents. Some of these misguided students make a qualified success in spite of difficulties, but a few find the whole atmosphere of industrial production or construction definitely unbearable. The reaction to even a brief exposure is conclusive evidence that they want no part of it. Under present schedules in coöperative programs this experience may not come until the end of the freshman year or beginning of the sophomore year, and for selection this may be a little late

but the damage, if any, is not irreparable for such students are often excellent material in the fields of mathematics or science and the academic programs which they have followed are by no means wasted.

If the methods of selection by examination and psychological tests were entirely accurate and dependable the functions inherent in the coöperative plan would not be necessary. But it is hardly possible that human evaluation can ever be exact, and border-line cases may still require practical test. The coöperative plan provides an opportunity for experimentation at an early stage in the program.

A few case histories may serve to illustrate the way in which students have found from experience the error of their first choice on entering college and also by practical experience have discovered a field in which they later had conspicuous success. For obvious reasons the individuals and the companies involved will not generally be named.

Mr. A entered as a student in electrical engineering in 1911 and was placed first in a general foundry and machine shop and then with an electric elevator company. He found the mechanical part of his work more interesting than the electrical and changed to mechanical engineering. He was placed with an engine company and developed almost a fascination for the generating of power. He is at present the vice-president of one of the largest aeronautical corporations in the country turning out horsepower at a rate unbelievable before the war.

The case of Mr. B is relatively simple as coöperative experience goes, but illustrates the way in which practical experience is both illuminating and convincing to a student. He registered as a mechanical engineer in 1925 and was placed with four different mechanical industries, including medium heavy machinery, automobile manufacture and plant maintenance. All of these he found too confining, but his work in plant maintenance had involved a little construction which he liked. He changed to civil engineering and was placed on the project of building a model community. After he graduated he held several responsible positions and finally became associated with the Tennessee Valley Authority, built and managed one of its towns and is now coördinator for the Federal Housing Commission. He was obviously not destined to design gears and cams.

Mr. C entered in 1928 as a chemical engineer and was placed in a chemical industry which used a large amount of mechanical equipment. He found more interest in the machinery than in the material which it processed. At the beginning of his sophomore year he changed to mechanical engineering and was placed with a company which manufactured a component used in a great variety of machines. Since his sophomore year he has never left the employ of this company and now is one of its district managers.

Perhaps these examples seem too simple. A more complicated case is that of Mr. D who entered in 1921 as a student in electrical engineering. He was placed for practical work with public utilities and manufacturing companies. His coöp jobs had included both electrical and mechanical work and finding the latter more to his liking he transferred to mechanical engineering. After a year in this field he was still dissatisfied and changed to civil engineering, from which department he graduated. All of this vacillation cost him some time but appar-

ently it was not lost for he is now chief engineer in one of the Kaiser shipyards on the west coast.

These illustrations have all involved marked changes from one field of engineering to another, distinguishing the square peg from the round hole, but there is a second order of fitting involving the recognition of the pentagonal peg and the hexagonal hole. This is a more difficult problem.

Twenty-five or thirty years ago there were far fewer and much less reliable "batteries" of tests than have since been developed, and the reactions of students to their industrial placement furnished at that time a valuable basis for guidance. Three paragraphs quoted from an article published by the late Dean Herman Schneider in the *American Magazine* April 1917, will illustrate the method of operation then and the basic principle still employed in the utilization of practical experience as a factor in guidance:

"Two boys came into our coöperative course together. They were of the same age, both unusually bright, both decidedly of a mechanical bent. One of them was put to work in a railroad shop, the other at a lathe in a manufacturing shop.

"The duties of the first boy were ever varying; he had to keep mind and body on the jump. The duties of the other boy were uniform and repetitive. Both of them were dissatisfied and began to slump in their work.

"The student in the railroad shop was slow in getting his mind adapted to new circumstances. The one at the lathe, on the contrary, had the type of mind that grasps things quickly, that revels in kaleidoscopic variation. So we had them exchange jobs. Both then did excellent work for the rest of the course."

It may be objected that this case history is oversimplified, which possibly it is, and that the cross transfer from production to maintenance is a trivial matter, which definitely it is not, since coöperative employment frequently leads to placement after graduation, and under-graduate adjustments may have a far reaching effect.

It is in this area of final sorting that the coöperative plan has something to offer which as yet has hardly been replaced by other methods.

Any fairly effective screening process would undoubtedly have placed in mechanical engineering both of the boys just described, and they would probably have gone there under their own power anyway. But "mechanical engineering" takes in a large territory and its subdivisions do not have sharp boundaries. Exact localization is therefore difficult. Even beyond the specific activities of an occupational placement are other matters which enter into satisfactory adjustment, such, for example, as the policy of management, the opportunities for advancement, working and living conditions.

All of these factors are important to a young man in selecting his specialty within a general field, and specifically in choosing his initial placement after graduation. It is doubtful that any abstract analysis can replace actual experience in the final steps of guidance which precede the placement of an engineering graduate, and the coöperative plan furnishes information both to the student and to his advisers which is very useful and valuable in these latter stages of college training.

It has been pointed out that the functions of selection and guidance merge indistinguishably at the beginning of a student's career. If it is the purpose of a technical program to provide a supply of trained young men for industry, the function of the engineering college has not been completed until

its obligation to both student and industry has been fulfilled in final placement following graduation. This placement should be more than a job following commencement. It should provide mutual satisfaction to employee and employer.

If this premise is admitted then guidance does not end with an examination, and interview on registration day with an official more or less qualified and more or less unprejudiced, but continues with counseling, which checks experience against the unpredictable changes which are to be expected in the adolescent, and merges finally with the function of placement, —placement based not alone on code numbers intelligible only to the U. S. E. S.—, but on first-hand experience with the type of job and with the organization in which employment will be found.

This merging of college training with placement in industry is one of the important contributions which the coöperative plan has to offer. Under normal conditions—if there ever were, or ever will be, normal conditions—a large percentage of coöperative students find positions after graduation with the firms with which they have worked as coöp students. The chief incentive for industrial companies to accept coöperative students is that firms may have a priority in obtaining those whom they wish to retain in the organization. For this reason placement is not a serious problem in coöperative institutions; from fifty to eighty-five per cent of the graduating class will generally continue with their former employers with practically no discontinuity.

It has been the purpose of this paper to suggest that the coöperative plan has something to add to, not to substitute for, other methods of selection and guidance, and that it integrates procedures from admission to placement. Its methods may be experimental, or, perhaps, more crudely, "cut and try." Until human beings can be subjected to caliper, schleroscope, and spectrograph, and until an individual can be prevented from changing in the period of college age, such empirical methods may have a positive value.

The Future in Engineering Education *

By E. G. BAILEY

Chairman, Bailey Meter Company; Vice-President, The Babcock & Wilcox Company

No specific definition of engineering education is adequate—its completion can never be attained, and probably no agreement or finalization of curricula can be reached. The rapid growth and progress of engineering during the past century has been largely due to the discovery and use of more of nature's laws than man had ever previously known. As each law is discovered, investigated, accurately expressed and classified, it can be accepted and used in the never-ending search for more laws and in the utilization of heat and power and the conversion of the material things of this earth to man's needs and uses.

In seeking an engineering education, one usually begins by taking one of several courses in one of our many engineering schools. The education is continued after graduation by experience in actual engineering work. Most large employers have special training courses which serve to acquaint the graduate with their specific line of engineering and teach him detailed application of the principles taught in the college courses.

There is the third step of becoming a member of one or more of the many engineering societies, thereby obtaining education from reading, presenting and discussing papers on engineering subjects which do, or at least should, pertain to the latest developments and problems in their respective fields. There is also the technical press with a still wider source of additional information.

Engineering education is on the post-war planning list of many educators. Many say that curricula should include more of the fundamentals and less of the rapidly increasing specialized branches, yet actual experience of the past has shown that as new inventions and developments are made, there is an inevitable demand from industry and the students for new courses in such subjects.

Many engineering schools have courses in as many as twelve or more different branches of engineering and throughout the country there are listed more than thirty different engineering courses. No one school has yet undertaken to give courses in that many branches.

Many educators, employers and graduates have expressed opinions that there is need for more economics, psychology, human relations, social sciences or whatever may be required to broaden the engineer's education along lines other than strictly technical knowledge and training. Many teachers have passed on to their students a great deal of personality through their

* Delivered at the 10th annual conference, Boards of Trustees of Colleges and Universities, at Lafayette College, April 21, 1944. (Published at request of Mineral Technology Division, S.P.E.E.)

inspirational leadership, which could not possibly be expressed in the prescribed courses or textbooks, but which fortunately has resulted in a much needed broadening of the viewpoint of engineers, in addition to their technical ability. Unfortunately, all students do not fully appreciate the opportunities presented to them by such teachers.

In the opinion of the author, the greatest criticism of our engineering education is the apparent failure of the teachers or the employers of the graduates to develop a sufficient supply of men for leadership and high executive positions.

In a recent talk before the Mineral Industry Education Division of the American Institute of Mining and Metallurgical Engineers (February 20, 1944) Dr. Nicholas Murray Butler said:

> I repeat what I have said a good many times, that as a result of present-day conditions, and of the war itself, the two intellectual occupations which are to be most important and of greatest service in the years immediately before us are engineering and medicine. The great advances which are being made in medicine are having and are bound to have a very remarkable and improving effect upon the health and the life conditions of the human race.
>
> To the engineers in one form or another we are to look for those new inventions, discoveries and applications which change the aspect of life and increase the effectiveness of almost, if not every, occupation of man.

With so many branches of our industry based upon engineering, it is desirable that the engineer should so extend and develop all qualities related to this expansive development that he can guide it along lines of still greater good. Many engineers have filled high executive positions very creditably, but the trend seems to have been that the great majority became so restricted to specialized engineering problems that they failed to grasp and advance in the fields of human leadership, judicial balance and economic concepts that are so necessary in industry today and will be even more so in the years to come.

Engineering education does teach one to be factual; one learns the law of conservation of energy; one learns the true significance of efficiency, all of which means that one cannot rightfully get something for nothing. To be true to his calling, an engineer must "keep his mind open until the facts are all in." Why, then, is there not a larger percentage of engineers among the leaders and executives of industry and the public utilities, dealing largely with engineering matters? Only a few years ago most of such companies were organized and headed by men, most of whom learned and knew engineering from the school of hard knocks, advancing from operating marine and stationary engineers, machinists and mechanics.

Perhaps we can gain the best conception of what kinds of engineering education are needed if we start with the invention of a new type of engineering equipment, such as the steam turbine, which superseded the steam engine to a very great degree within the memory of many persons present.

The development of the steam turbine required:

1. Engineering design — involving thermodynamics, strength of materials, flow of fluids, and many other features.
2. Experiments and research without end, some of which are still continuing.
3. Technicians of a high order to fabricate the parts.

4. Metallurgists, as high temperatures and stresses were reached.

5. Salesmen, with the necessary technical background.

6. Manufacturing, tooling and production methods.

7. Installation and servicing its operation from time to time.

8. Through it all, vision, faith, persistence, executive management and financing—all of these elements and of a high order were required to coördinate Nos. 1 to 7 and bring about success for the benefit of mankind.

Who better than an engineer with the qualifications of No. 8 can provide the overall coördination required? In other fields of development, the absence of sound engineering knowledge, plus executive ability, has wasted much time and money on false and impossible pipe dreams under the pretext of revolutionary invention or has prevented or deferred progress upon worthy projects only to find that years later others with better executive engineering judgment brought about success. The men who can perform jobs Nos. 1 to 7 and do them well, must very often concentrate too much upon their specific problems to have the time, together with the ability, perspective, foresight, and inclination to evaluate the job to be done.

Our engineering education has been largely devoted to training men for Nos. 1, 2, 4, 6, and 7, with too little attention to training of technically educated salesmen (No. 5) and the machinist or technician (No. 3).

To summarize the foregoing statements, we need and have been training, in the most of our engineering schools, skilled and competent engineers who have a creditable record as inventors, designers, test and development engineers, superintendents, managers, some good sales engineers and a few top-ranking executives.

Trade schools, manual training high schools, shop apprentice training courses, have trained a goodly number of "technicians" or men with skills such as draftsmen, tool makers, machinists, welders, foremen. These ranks have also been supplied in some measure from graduates from some of our engineering schools.

The executive is supposed to grow or sprout out of the graduates of the engineering school or even from the ranks of the technician by some magic. The fact that more do not do so leads many to realize that there is something lacking in our engineering curricula of today. We find many lawyers, accountants, and men with general business education stepping into executive positions of corporations doing a strictly engineering line of business. Is there something gained by these professions, either in school or later experience, that gives them abilities which the engineer has not attained or has not had a chance to gain from our present curricula or training? Many lawyers or business-trained executives who have not also acquired a goodly knowledge of engineering, are at a disadvantage in that they must lean heavily on others for many decisions.

The diagram on Chart No. 1 will perhaps clarify the situation presented up to this point in this paper. This chart is labelled a "Flow Sheet of Materials, Engineering, Industry and Business." *

This diagram starts with a general classification of all materials available from this earth—plant and mineral products, timber, non-metallic minerals, metallic minerals, fuels, water and

* Chart follows conclusion of this address.

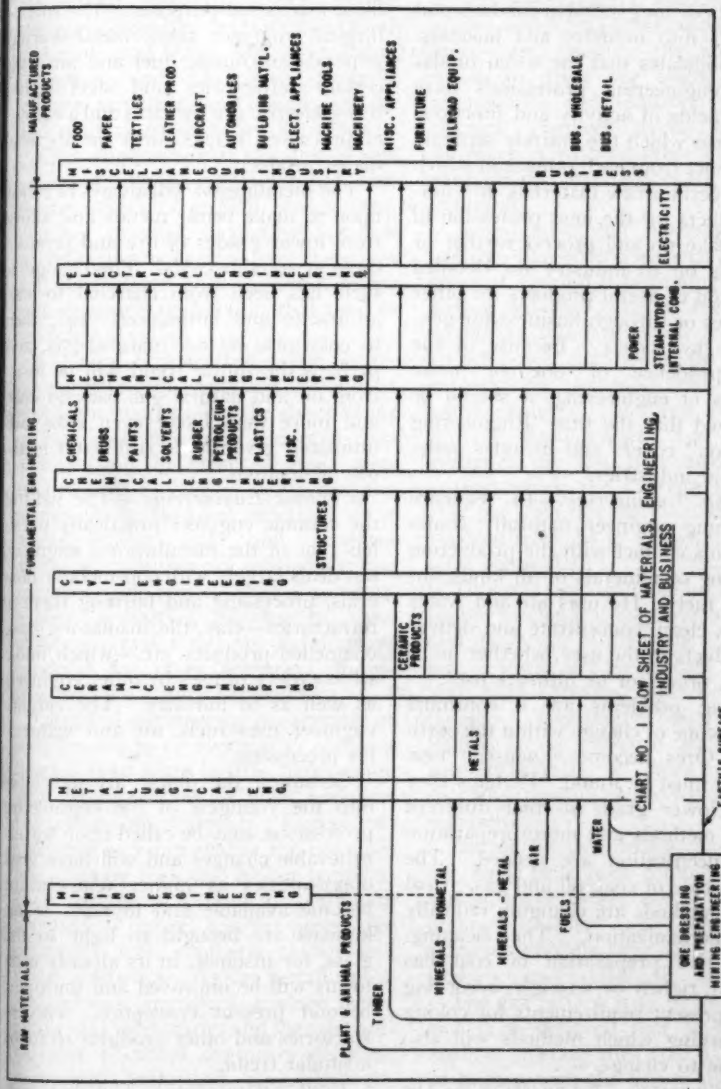
RAW MATERIALS
FUNDAMENTAL ENGINEERING
MANUFACTURED PRODUCTS
MINING ENGINEERING
METALLURGICAL ENG.
CERAMIC ENGINEERING
CIVIL ENGINEERING
CHEMICAL ENGINEERING
MECHANICAL ENGINEERING
ELECTRICAL ENGINEERING
INDUSTRIES
BUSINESS
PLANT & ANIMAL PRODUCTS
TIMBER
MINERALS - NONMETAL
MINERALS - METAL
FUELS
AIR
WATER
METALS
CERAMIC PRODUCTS
STRUCTURES
CHEMICALS
DRUGS
PAINTS
SOLVENTS
RUBBER
PETROLEUM PRODUCTS
PLASTICS
MISC.
FOOD
PAPER
TEXTILES
LEATHER PROD.
AIRCRAFT
AUTOMOBILES
BUILDING MAT'L.
ELECT. APPLIANCES
MACHINE TOOLS
MACHINERY
MISC. APPLIANCES
FURNITURE
RAILROAD EQUIP.
BUS. WHOLESALE
BUS. RETAIL
POWER
STEAM-HYDRO
INTERNAL COMB.
ELECTRICITY
ORE DRESSING AND PREPARATION
MINING ENGINEERING
EARTH'S SURFACE
CHART NO. 1 FLOW SHEET OF MATERIALS, ENGINEERING, INDUSTRY AND BUSINESS
E.E.S. 9-21-44

CHART 1.

air, and shows them passing through the hands of the general or fundamental engineers into industry and business.

This indicates that the seven fundamental engineering professions have definite fields of activity and functions to perform which are entirely separate and distinct from each other and which convert certain raw materials into usable products for the next profession in line to take up and process further or else pass on to industry for detailed fabrication of useful products for other industries or through business for general use by society. Because of the inter-dependence of one or more branches of engineering, it should be recognized that the title "Engineering Education" covers and includes many fields and industries.

Mining Engineering.—In sequence the mining engineer naturally comes first in his contact with the production or mining of minerals of all kinds, including fuels. He uses air and water to mine, clean, concentrate and deliver his products to the user, whether he be smelter, processor or ultimate user.

Mining problems are a continual kaleidoscope of change within the earth itself. Ores become exhaused; new deposits must be found. Perhaps they are of lower grade so that different mining methods and more preparation and concentration are needed. The same is true of coal, oil and gas. Coal mining methods are changing radically with mechanization. The cleaning, sizing, and preparation of coal has changed, rightly or wrongly, according to the present requirements for coking and burning which methods will also continue to change.

Metallurgical Engineering. — The metallurgical engineer comes next in the flow sheet, taking the metal-bearing minerals and smelting or processing them into metals and often alloying them for special purposes. The metallurgical engineer takes metal-bearing minerals and, using fuel and air with certain refractories and steel structures, electric arc furnaces and a variety of processes, brings forth metals as a major product.

The metallurgist will always be called upon to make better metals and alloys from lower grades of ore and produce them at suitable costs. The change in fuels has been from charcoal to raw anthracite and bituminous coal; then to coke plus oil and natural gas, and perhaps the future trend will be away from oil and natural gas back to coke and more than likely even coke will ultimately give way to still better methods of smelting.

Ceramic Engineering.—The field of the ceramic engineer practically parallels that of the metallurgical engineer, but deals largely with non-metallic minerals, processing and burning them in refractories—clay, tile, insulators, glass, enamelled products, etc.—which find a wide variety of uses by other engineers as well as in industry. The ceramic engineer uses fuels, air and water in his processing.

Ceramics, the oldest art developed into the youngest of the engineering professions, may be called upon for unbelievable changes and will have great opportunities as higher temperatures become available and myriads of unknowns are brought to light so that glass, for instance, in its already many forms will be improved and multiplied beyond present conception, with refractories and other products to follow a similar trend.

Civil Engineering.—The civil engineer, belonging to the oldest of the engineering professions, is in some ways the most limited of all. He

takes the steel and other products of the mining, metallurgical and ceramic engineers, together with timber, earth and rock, and builds highways, dams, irrigation and navigation projects, bridges, structures and handles sewage and sanitary products for all others.

Civil engineering is old but it will never die. It may pass through successive stages of growth, standardization and apparent stagnation, but how many structures ever have been, or will be, replaced with the same design and structural material as that used in the original?

Chemical Engineering.—The chemical engineer may be classed as the most prolific in that he takes the entire range of raw materials from the earth, sea and air, and, by means of fuels, electricity and a variety of techniques, brings about chemical reactions on a manufacturing scale and produces acids, a multitude of chemicals and reagents, pulp, paper, paints, solvents, rubber, synthetics, plastics, etc., and passes on raw materials and finished products for other engineers, industries and the ultimate consumer.

Chemical engineering is currently so well known to everyone who reads or listens, that more words here would only be repetitious of what everyone has seen or heard already. Except that everyone may not realize the possibilities of using high and higher temperatures for the processing of petroleum products to recover a larger percentage of motor fuel, synthetic rubber and other synthetics. As the metallurgical and ceramic engineers produce better alloys and refractories and the mechanical and electrical engineers do their part with fuels and electricity, the chemists' field will further expand.

Mechanical Engineering.—The mechanical engineer takes the products of all four engineers described and constructs power plants, machinery of all kinds, which, together with fuel, air and water, produce the power with which to drive our ships, railroads, automobiles and industry. The mechanical engineer works closely in conjunction with all other branches of engineering and especially so with electrical.

Some think that mechanical engineering, like civil engineering, has become of age and is beginning to standardize, but that belief is true only in so far as standardization is justified. In the power field alone, the mechanical engineer, working with the electrical engineer, has been responsible for the great growth and improved efficiency in the past two decades during which the average pounds of coal per kwh. for all plants have been reduced from 2.4 to 1.3 with the better ones below 0.9.

This was practically all accomplished by the mechanical engineer on the fuel and steam side of the cycle. The burning of lower grades of coal continues with ever-increasing efficiency and reliability. The larger boiler units for higher steam pressure and temperature practically all burn pulverized coal and remain in service with great reliability.

During the past decade the boilers of our navy have been completely re-designed, made larger and to operate at higher pressures and temperatures. Stationary boilers have been revolutionized even more during the same period.

The gas turbine may be in the offing and it is believed that it should be made to operate with coal as a fuel to be in step with the future fuel supply. Its field of application will probably be limited to certain sizes and uses.

Aviation, automobile, power for the

navy and merchant marine, as well as locomotives, all fall within the province of the mechanical engineer with some record of accomplishment and more yet to be done. Fuels, thermodynamics and power are the life blood of our civilization and this is the distinct field of the mechanical engineer.

Electrical Engineering.—The electrical engineer takes the power from the mechanical engineer to produce electricity and distribute it to operate appliances and communication systems for multitudinous and practically unlimited use.

The general knowledge of electrical engineering in its many applications within the field of communication is so vast and greatly publicized that no more need to be said here.

Fundamental Engineering Courses.—The seven engineering branches enumerated seem to cover all that are needed to complete the engineering profession. They all deal with materials, forces and energy in a fundamental and complete way. Furthermore, they are always dealing with changing conditions.

Each branch of industry is producing things for others to use. The products of each industry are largely used by other industries or by the ultimate consumer. The general public, which includes the high-school graduate about to enter college, knows very much more about the finished products of industry than it does about the inter-industry products which are not so tangible and spectacular, but are often of much greater importance.

Undoubtedly, the greatest and most far-reaching engineering problems lie within the needs of inter-industry development where a change in one calls for changes in others which can only be foreseen and properly met by those engineers of broad education, perspective and foresight, who know something, at least, about other branches of engineering than the one in which they are specifically allied.

For instance, the development of the railroads caused outstanding changes in the steel industry; the needs of the steel industry influenced changes in fuel supply, such as the by-product ovens for coke and gas; the airplane has been a factor in the production of aluminum and magnesium; the automobile caused a revolution in petroleum refining; the seeming limitation in petroleum supply will influence the cost and possible sources of motor fuel. Fuel availability and cost will affect the future of the diesel locomotive, the much talked of gas turbine and engineering activities in many directions. The development of the steam turbine, previously referred to, came at a time when it and its inherent thermodynamic characteristics resulted in advances in steam pressure, steam temperature, condenser vacuum, stage heating and larger units. These in turn had a great influence on steam boiler design, condensers, and electric generators now cooled by hydrogen to keep in step in the race.

The steam turbine, more than any other one development, helped to bring about the low cost and extensive use of electricity, and improved the performance of our navy and large merchant ships. Too much credit cannot be given to the executives who had the vision and persistence to follow that development from its nebulous conception to its adult growth of today, even though it took years to offset the millions of dollars of development expenses.

Are we training engineers today who can think straight and plan correctly

and efficiently on the development and application of the gas turbine, the best plans for processing the right fuels and the best methods for their use in a world that is already geared to power in war and in peace?

Sixty per cent of our coal is burned in houses, smaller industries and railroads at a decidedly lower efficiency than should be obtained. For each barrel of gasoline from our refineries a barrel of fuel oil goes to furnaces to be burned for heat that could be supplied by coal, and some unthinking editors or the specialized engineers are calling for gasoline from coal before the available petroleum is as effectively used as it should be.

There is a great need for an engineering education which will train men to be general engineers acquainted with the essence of all of the seven branches of fundamental engineering. Not every school now giving engineering courses should introduce additional courses in general engineering for several reasons:

First and most important, they do not all have a sufficiently qualified and coördinated faculty personnel to properly teach the correct essence of each of the seven branches without too much specialization or too much generalization.

Second: There will not be a large enough enrollment in the beginning to justify many schools giving general engineering courses until they have been perfected and sold—which will take some time.

Third: The problems for planning courses in general engineering should be thoroughly discussed and planned before the actual start is made. It is too important and too much needed to make a quick false start and thereby handicap the plan for its ultimate good.

There is at best a twenty to thirty year time lag between the planning of a course of study and the ripened product in the form of the trained and experienced graduate ready for leadership and executive positions. We should start now to properly educate and train men needed at the helm in 1965.

General Engineering.—The author is presenting this plan for general engineering courses for consideration and discussion with only some general thoughts as to the curricula. It is believed that it might well incorporate some of the following features:

1. To be a four-year course.

2. Lead to bachelor degrees in any one of the seven principal branches of engineering.

3. The first three years might be identical for all seven branches. The first year not very different and perhaps identical with the regular engineering courses now given in each of these branches, but including revisions which are now in the making by the Society for the Promotion of Engineering Education and by the schools, themselves.

4. The second and third years would depart from present specialized courses. They would give every student a thorough cross-section of the essence of each of the seven branches of fundamental engineering; their relation to each other, their collective place in industry and society with respect to economics, orderly technological advancement and the betterment of mankind. To do this, these courses should include what is needed in the way of business, law, social relations and broad perspective which are essential requirements of the leaders of the future.

5. The fourth year, each student would specialize in one of the seven branches for his major and degree,

which he had chosen as his nominal profession.

6. The graduate would naturally select an employer where problems exist beyond the scope of one particular branch of engineering, which would include many of the larger companies and a surprisingly large percentage of smaller companies, a number of which do not now regularly employ graduate engineers. In any case, the employer should recognize his opportunity in obtaining the services of a man with such broad training and give him corresponding opportunities for growth and advancement.

The author is aware that some schools already have courses in general engineering, administrative engineering, business engineering, but none with which he is acquainted come anywhere near giving the background now being recommended.

Specialized Engineering Courses.—The great majority of the engineering courses given today are rather highly specialized in an effort to make a finished engineer in a particular line with the apparent idea that he can start to work and produce results almost immediately.

The larger company employers have training courses which the graduate normally spends one to two years in taking to become acquainted with the company's product, and during which he and his employer may decide upon the branch of work for which he is best suited. In smaller companies or in miscellaneous jobs, the graduate nearly always has a period of acclimation and learning of developments of later vintage than can possibly be taught at school.

If any general suggestions are in order for the consideration of schools about to reconsider their curricula, they might, in the author's opinion, be summed up as follows:

1. Teach less detailed application such as machine design and engineering products as now existent.

2. Teach more of the fundamentals such as English, mathematics, physics, and especially chemistry.

3. For many courses, fuels, combustion, metallurgy and flow of fluids are needed beyond that being taught.

4. Shop work is still helpful in some branches of engineering; while engineering laboratory testing is needed in others.

5. Economics and human relations are often needed beyond that now being taught.

6. Salesmanship is sadly lacking in most engineering courses.

Salesmanship.—Everyone has something to sell. The graduate must sell himself, and keep himself sold, to one or more persons if he is to hold his position and advance. Many industries are sending a larger percentage of their organization staff, from shop foremen to top executives, to schools in salesmanship, not to sell the company's product alone but to sell themselves to the men who work for them as well as to those for whom and with whom they work. Many an engineer has said to the author, "Why don't our schools teach us salesmanship?" What is salesmanship but an understanding human approach, plus a thorough engineering knowledge of the subject?

Specialization.—There is a question in the minds of many as to whether or not it is right to continue the present trend of adding new courses to meet the apparent need from industry and the students to specialize in new activities within the field of engineering.

It is believed that a study of the engineering societies in the United States

	SCIENTIFIC, EDUCATIONAL, AND MISCELLANEOUS RELATED TO ENGINEERING		MINING & METALLURGICAL ENGINEERING		CERAMIC ENGINEERING		CIVIL ENGINEERING	
	FOUNDED	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP
	1727 AM. PHILOSOPHICAL SOC.	528						
1820	1824 FRANKLIN INST.	5,300						
1830								
1840	1846 SMITHSONIAN INSTITUTION							
	1848 AM. ASS'N. FOR THE ADVANCEMENT OF SCIENCE	23,782						
1850							1852 AM. SOC. OF CIVIL ENGINEERS	
							1857 AM. INST. OF ARCHITECTS	
1860	1863 NATIONAL ACADEMY OF SCIENCE	389						
	1866 NATIONAL BOARD OF FIRE UNDERWRITERS (COMPANIES)	204						
1870			1871 AM. INST. OF MINING ENGINEERS — METALLURGICAL ENGINEERS ADDED IN 1919	19,500				
1880							1881 WATER WORKS ASS'N.	
	1885 AM. ECONOMIC ASS'N.	3,800						
	1886 THE SOC. OF THE SIGMA XI	45,000						
	1888 AM. MATHEMATICAL SOC.	2,600						
1890	1888 GEOGRAPHICAL SOC. OF AMERICA	880						
	1893 SOC. FOR THE PROMOTION OF ENGINEERING EDUCATION	3,500					1894 AM. PUBLIC WORKS ASS'N.	
							1899 AM. RAILWAY ENGINEERING ASS'N.	
	1899 AM. PHYSICAL SOC.	4,000			1898 AM. CERAMIC SOC.	3,000	1899 AM. SOC. LANDSCAPE ARCHITECTS	
1900	1902 AM. SOC. FOR TESTING MATERIALS	4,840	1902 STEEL FOUNDERS SOC. OF AMERICA	200			1902 PORTLAND CEMENT ASS'N. (COMPANIES)	
			1907 ASS'N. OF IRON & STEEL ENGINEERS	2,000			1905 AM. CONCRETE INST.	
			1908 AM. IRON & STEEL INST.	1,345				
1910	1915 MATHEMATICAL ASS'N OF AMERICA	2,500						
	1918 AM. STANDARDS ASS'N.	2,000						
			1919 AM. WELDING SOC.	7,200				
1920	1920 MINERALOGICAL SOC. OF AMERICA	950	1920 AM. SOC. FOR METALS	11,500			1920 SOC. OF AM. MILITARY ENGINEERS	2
1930								
	1932 ENGINEERS COUNCIL FOR PROFESSIONAL DEVELOPMENT	24						
			ABBREVIATIONS: AMERICAN — AM.; ASSOCIATION — ASS'N.; INSTITUTE — INST.; SOCIETY — SOC.					
1940			☐ INDICATES LEADING ENGINEERING SOCIETIES IN EACH FUNDAMENTAL BRANCH					

CHART NO. 2 ENGINEERING SOCIETIE

ORGANIZATION DATES & APPROXIMATE MEMBERSHIP, 1943

CIVIL ENGINEERING		CHEMISTRY AND CHEMICAL ENGINEERING		MECHANICAL ENGINEERING		ELECTRICAL ENGINEERING		
	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP 1943	FOUNDED	MEMBERSHIP 1943	
								1820
								1830
								1840
								1850
[illegible]C. OF CIVIL ENGINEERS	18,000							
[illegible]ST. OF ARCHITECTS	4,740							1860
				1867. MASTER CAR BUILDERS ASS'N 1868. AM. RAILWAY MASTER MECHANICS ASS'N.				
		1872. AM. GAS LIGHT ASS'N 1876 AM. CHEMICAL SOC.	35,000					1870
[illegible] WORKS ASS'N.	4,739			1880 AM. SOC. OF MECHANICAL ENGINEERS	16,500	1884 AM. INST. OF ELECTRICAL ENGINEERS	20,200	1880
				1880 AM. SOC. OF NAVAL ENGINEERS	1,600	1885. NATIONAL ELECTRIC LIGHT ASS'N.		
[illegible]BLIC WORKS ASS'N.	800			1893 SOC. OF NAVAL ARCHITECTS & MARINE ENGINEERS	3,200			1890
[illegible]ILWAY ENGINEERING ASS'N.	1,987			1893 RAILWAY FUEL & TRAVELLING ENGINEERS ASS'N.	300			
[illegible]C. LANDSCAPE ARCHITECTS	420			1895 AM. SOC. OF HEATING & VENTILATING ENGINEERS	3,340			
[illegible]D CEMENT ASS'N. (COMPANIES)	80	1902 ELECTROCHEMICAL SOC. INC.	1,400	1902 MASTER BOILER MAKERS ASS'N.	430			1900
[illegible]NCRETE INST.	1,826			1904 AM. SOC. OF REFRIGERATING ENGINEERS	2,790			
		1908 AM. INST. OF CHEMICAL ENGINEERS	3,700	1905 SOC. OF AUTOMOTIVE ENGINEERS 1907 AM. SOC. OF AGRICULTURAL ENGINEERS	8,500 1,220	1906 ILLUMINATING ENGINEERS SOC.	3,600	
				1910 AM. INST. OF REFRIGERATING ENGINEERS	1,600	1912 INST. OF RADIO ENGINEERS, INC.	9,814	1910
		1915 TECHNICAL ASS'N PULP & PAPER INDUSTRY	2,200					
		1918. AM. GAS ASS'N. 1919 AM. PETROLEUM INST.	5,500 4,000	1919. AM. RAILROAD ASS'N				
[illegible]. MILITARY ENGINEERS	22,000	1923 AM. INST. OF CHEMISTS	2,000	1921. AM. RAILWAY ASS'N				1920
				1932 INST. OF AERONAUTICAL SOCIETIES, INC.	3,000	1933. EDISON ELECTRIC INST. (COMPANIES)	200	1930
				1936. ASS'N. OF AM. RAILROADS (SYSTEMS) 1936 SOC. FOR THE ADVANCEMENT OF MANAGEMENT	130 2,200			
		INDICATES SOCIETIES FORMED FROM COMBINATION OR REORGANIZATION OF THOSE MARKED • IN SAME COLUMN				1940 TELEVISION ENGINEERS INST. OF AMERICA E.E.B. 4-21-44		1940

NO. 2 ENGINEERING SOCIETIES

[illegible]GANIZATION DATES & APPROXIMATE MEMBERSHIP, 1943

is worthwhile as a part of this discussion. The organization and continuation of these societies in a free democratic country is irrefutable evidence of the need for education or supplemental education in the different main branches of engineering as well as in the special branches, or sub-divisions, which still continue to be formed as new developments in engineering take place.

The organization of a new society for the purpose of specializing in a branch of engineering is evidence of new activity in that branch, which is not being satisfied, or at least its founders think it cannot be adequately satisfied by any existing society. New societies are still being formed even though the older and larger engineering societies have made considerable effort by adding new professional divisions, within their present organizations, to satisfy any reasonable need.

Chart 2 is a fairly complete list of societies which are organized for the general betterment and education of their respective professions or some branch of a profession. They are arranged vertically in chronological sequence, giving the date of organization and the approximate membership as of 1943. The first vertical column gives societies devoted to scientific, educational and miscellaneous activities, all related to engineering education. The others are arranged horizontally in accordance with the flow sheet arrangement on Chart 1.

Some of the sub-branch societies are often classified as industry institutes, or groups closely allied with the business or commercial aspects of an industry. However, many of those so considered also have technical papers and discussions of a highly educational order, so that one specializing in these lines is greatly helped by such papers and discussions.

Today we refer to the "Four Founder Engineering Societies" including Civil, Mining, Mechanical and Electrical. Those and three other important societies follow:

	Founded	Approximate Membership 1943
Amer. Society Civil Engineers	1852	18,800
Amer. Institute of Mining and Metallurgical Engineers (Originally Mining only — Metallurgical added)	1871 1919	14,500
Amer. Chemical Society	1876	35,000
Amer. Soc. Mech. Engineers	1880	16,500
Amer. Inst. Elect. Engineers	1884	20,200
Amer. Ceramic Society	1899	3,000
Amer. Inst. Chem. Engineers	1908	3,700

The American Chemical Society has preferred to be classified more as a scientific than an engineering society, although it includes in its membership many chemists who have been outstanding in developing chemical engineering and instigating such curricula in many engineering schools shortly before the founding of the American Institute of Chemical Engineers in 1908. Chemistry is universally recognized today as an important factor and one of our most important branches of engineering.

Courses in ceramic engineering were initiated at Ohio State University in 1894 by Edward Orton, Jr. This was the first collegiate grade ceramic course in the world. There are now about twenty schools with courses in ceramics. The American Ceramic Society was incorporated in 1899 and now has eight divisions.

By 1919 the profession of metallurgical engineering had been sufficiently established to find a place as a society, but instead of starting an independent society it joined with the mining engi-

neers as the American Institute of Mining and Metallurgical Engineers.

The more or less automatic growth or natural growth of the engineering profession into seven branches seems to have satisfied the requirements for the past forty years.

The Founder Societies have also added many professional divisions to their organization chart to take care of the diverse and specialized interests to a considerable degree, or else there would likely have been other societies organized to cover the sub-branches in the modern engineering field.

Is it not evident that specialized engineering courses must be taught in a certain number of our schools to meet these demands as the first step in our engineering education? All schools should not teach all branches of engineering. Perhaps some are already being taught in too many schools. No course should be taught unless it has a competent teacher. Experience has shown cases of a teacher well-versed in a field of engineering starting a course in his specialty. If he has no worthy successor, the course should be dropped rather than let it sink into mediocrity.

Technicians.—Many technical or trade schools are doing a good job in training men as technicians, and when so trained and properly located they are usually satisfied with their work and place in industry. Many have the ability to advance to similar rank with the engineering graduate. When the engineering graduate does not advance beyond the rank of technician, there is something wrong. Perhaps such a man should not have gone to college; perhaps the college training was not adequate, perhaps the employer is at fault, or sometimes the man, himself, has changed or slumped. At any rate, there seems to be so much of this that the schools should consider it carefully as having the first and perhaps the greatest responsibility.

Ability and Personality of Teachers.—There is no question but that the strength or weakness of a course or department with identical curricula will depend upon the ability and personality of the teachers, individually and collectively. Courses are often flexed to meet the strength or whims, as the case may be, of a faculty member.

The visitation to many schools over many years for the employment of graduates taught the author that there was often a time lag between the reputation of a school or department and its true value. The passing of personnel and the succession of others often makes a real change for better or worse. The student product changes promptly, while the general public, industry and alumni may often retain the impression of the past. One cannot teach well that which one does not know.

Perhaps the recognized need for the teaching of such subjects as human relations can be taught without textbooks or any special course if there are enough individuals in each faculty who can pass on to the student personality a right state of mind, inspirational leadership, and the ability to understand people.

The author is a bit skeptical as to whether any individual course of study can be added to our engineering curricula that will make up for the rather prevalent lack in the teachings that used to be obtained from the home, the Sunday School and the Church. This subject deserves all and more attention than it has yet received.

Graduate School and Research.—Some may think that graduate courses will meet the requirements which are recommended in the first part of this

discussion as fundamental engineering. There are really two very different subjects involved—the general engineering courses are needed for definitely broadening the scope of education, while graduate courses are usually specializing. The latter carry a student on to some specific or specialized branch, which can often be better done in industry. It is the author's opinion that many schools might do better if they considered suitable work in industry the equivalent to an advanced degree as a requirement for teaching.

There seems to be an impression that any school or graduate department may hang out a shingle with "Research" on it and expect results. It requires more than the wish to do effective research work, and a great deal of time and money is being wasted in this way. There are many qualified schools doing effective work in this direction, but it should be recognized that all are not equally competent.

There are many kinds of research on large projects that can be done best in industry, and these should be able to obtain a greater number of graduates that are inventive and research-minded than appear to be available. There is a disagreement as to whether an inventor is born or trained. The author thinks they can be trained or at least latent talent can be improved, but apparently very few can teach this subject effectively.

Resumé

1. There is some belief in the educational profession that a change is needed in the curricula of engineering education.

2. Some recommend the teaching of the fundamental sciences more thoroughly.

3. Some recommend the teaching of more specialized engineering. The trend has been toward a greater number of specialized courses, some of which have not always maintained the highest standard of engineering.

4. There is a recognized need for more human relations.

5. Engineering of some kind should be taught to a larger percentage of our population than is now the case. Better definitions are needed to distinguish between engineers and technicians or men of skills.

6. It is obviously impossible to go in two directions at once, therefore, the time may have come for a fork in the road with well-planned courses in each branch that will fulfill both Nos. 2 and 3 respectively.

7. The author recommends that serious consideration be given to the teaching of the seven general engineering courses, viz., mining, metallurgy, ceramics, civil, chemical, mechanical and electrical, as a coördinated group with the first three years identical, dealing particularly with mathematics, drawing, English, physics, chemistry, economics, business, salesmanship, and a broad related picture extending from geology, minerals, fuels, smelting, ceramics, strength of materials, structures, thermodynamics, power and electric generation.

There should be a course in research and invention. Trained professional engineers should have vision as to planning, and if possible a better appreciation of research and invention even if they themselves cannot be actually trained to be inventors, although they might at least become more efficient inventors if they have any talent along this line. During the

fourth year, the student should concentrate on the specific course of his choice, leading to a bachelor's degree.

8. Engineering courses, being taught in our schools, should be continued with some modification and improvement. These courses would be more specialized than those given under general engineering in No. 7.

Trustees' Duties.—Regardless of whether changes or transitions in the courses of study take place quickly, or gradually, as they have in the past, it is believed that more responsibility will and should fall upon the trustees, presidents and faculties of our universities and colleges than has sometimes been appreciated heretofore.

The selection of the faculty is all-important and to keep a well-balanced school there must be intelligent and unprejudiced coöperation. It is the student that is important and not the personal wishes of the individuals who comprise the faculty.

The proper judgments in advancement, retirement and succession are most difficult but all-important problems in the schools as well as in industry. Personnel specialists are coming more to the front as essential factors in this problem.

When an organization of any character is functioning satisfactorily and efficiently, all should share the credit. When an organization is inefficient and working at cross purposes, the trouble is at the top. That means in the case of an institution of learning that the responsibility for success or lack of it lies with the trustees or their selected deputies.

Comments on the Future of Engineering Education

By ALLEN H. BLAISDELL

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The Presidential address of Robert E. Doherty at the fifty-second annual meeting of the S.P.E.E.* in June 1944 records a definite transition period in engineering education in the United States. For more than two decades the confused and rapidly changing panorama of the nation's industrial life, as well as the growing crisis in general overall social relationships, has made evident to thoughtful citizens the acute need for fundamental, energetic and far-reaching actions if the nation's well-being is to be improved and maintained. Since our educational system is one of our most important instruments of social indoctrination and control, it is here that most active steps have been taken to anticipate and prepare for a future of threatening aspects. Social relations programs have been incorporated into the curricula of our high schools and efforts made to establish a training which would enable the large majority of graduates, who do not continue on into college, to fit more effectively into the social fabric. It is this same purpose that is now energizing our professional groups, and has culminated in the investigations and actions of the S.P.E.E.

College and university administrations have eyed the curricular revisions of our secondary and high school with some misgivings, and not a little hostility, but academic conservatism is beginning to weaken and shows signs of cracking when confronted with dynamic national needs. In this respect engineering educational institutions have been as steadfast in clinging to established practices as any of the centers of liberal learning. But the very nature of the engineers' activities is such as to make him more sensitive to the growing complexities of our industrial life than perhaps any other of our professional groups. For this reason we can expect engineering schools to be among the first to make basic and vital changes in their educational programs.

A careful study of the S.P.E.E. reports * for 1940 and 1944 in conjunction with the summarizing statements contained in Dr. Doherty's address impresses the reader with the feeling that the educational question for engineers, at least, is being answered in a thoroughly pragmatic, logical and probably more realistic spirit than is generally recognized at the moment. Of course the preliminary steps only have been taken and the much more difficult one of putting the proposed revisions into operation remains for the most part to be carried out. Certainly any notion that long-established educational habits or procedures can be abruptly changed for the better in a brief period of years must go by the board.

* See Volume 35, No. 1, September, 1944: JOURNAL OF ENGINEERING EDUCATION.

* 1940 Report on Aims and Scope of Engineering Curricula. 1944 Report on Engineering Education After the War.

From an educational viewpoint it is essential that the engineer shall have a more precise and correct idea of what constitutes his rightful field of professional activities. This need has been sensed by Dr. Doherty, who proposes an unostentatious, conservative and precise defining statement of what constitutes the engineering profession. The widespread lack of understanding among engineering groups, and others as well, as to the rightful domain of the engineers' professional activities has for a long time been something of a joke. Consequently any rational program for renovating our engineering curricula must first rest on the general willingness on the part of the engineering profession to accept a more sober and restrained notion as to relative importance of the profession in the nation's industrial life.

The suggested division of the engineering curricula into parallel sequences of scientific-technological and humanistic-social subjects, with about eighty per cent of the students' scholastic load apportioned to the former, and twenty per cent to the latter, coincides with the corresponding time distribution under established programs where twenty per cent of the student time is given over to elective subjects in economics, history, literature, etc. But it is to be noted that under the new dispensation isolated subjects without any apparent connection are discarded. The primary thought behind the entire proposal is to establish a much better integrated and broader curriculum than is now the case in our engineering colleges. The difficulties involved need not be minimized but they can and must be eliminated.

The committee reports of the S.P.E.E. have set up specific objectives for the two curricular divisions just referred to, and their successful attainment by any educational institution will be intimately related to the solutions of accompanying problems dealing with the selection of faculty personnel, selection of entering students, departmental organization, interdepartmental relationships, and finally educational methods. Any one of these merits consideration, but lack of experience and time forces the writer to direct his rather random remarks toward the more specifically pedagogical aspects of the current educational practices as affected by the new program.

The established curriculum for engineering students is constructed around separate and none too well integrated courses in the basic sciences of mathematics, physics, chemistry and mechanics, followed by more or less specialized courses in engineering departments which function as independent units. As a kind of side issue, and sop to the liberally-minded citizen, service departments are assigned a modicum of time to instill into a reluctant student mind some appreciation of literature, language, philosophy, psychology, etc. This type of organization has been in existence for at least five decades, and its general limitations are rather well recognized.

Instructional methods congenial to the handling of large classes have perpetuated the lecture-recitation system into the dynamic environment of our modern culture. Textbooks used in the specifically engineering courses have gradually assumed a more and more elementary character which is hardly conducive to genuine mental development. One suspects that the generally accepted promotion policy which encourages young and inexperienced instructors to get into print has contributed not a little to the mediocr-

nly of much of the text material which is copiously advertized by book publishers.

The emphasis placed on the "engineering method" by the committee reports is, historically speaking, only one of a long series of pointed criticisms directed at the general ineffectiveness of the specialized engineering courses given during the last two years of the standard engineering curriculum. The "engineering method" as described is in essence the scientific method applied to the solution of engineering problems. In engineering practice this method is the normal approach to any problems involving diverse elements of both a technological and economic nature. Necessarily to bring about a formal introduction of any such procedure into the engineering educational framework requires considerable revision, coördination, and possibly the combining of established specialized courses into a few better integrated studies.

The "engineering method," in a form modified by local circumstances, has long been an acceptable procedure in the operation of senior engineering design courses. Under the inspiration of teachers well versed in the art and science of engineering practice such courses take on the color of project problems to which the students (we suspect that in some cases these will be the select few, the hoi-poloi being relegated to problems of a rigidly prescribed pattern) give intensified effort under the tactful guidance of the instructor. In a very considerable measure such courses have been the only ones which have afforded students a real opportunity for reviewing and integrating scientific principles and of applying the analytical sciences to problems of an engineering type. The successful operation of a well-balanced design course means that the student will be trained to a proper "method of attack," concurrently with a much-needed review of fundamentals.

Revision of the engineering curricula to conform to the requirements of the new scientific-technological stem should largely result in the eventual weakening of the formal lecture-recitation system, and its replacement where f e a s i b l e by conference-discussion groups, particularly in the upper two years. Departmental exclusiveness, so typical of standard curricula, must yield to a greater degree of coördination and correlation of course contents. For example, it is reasonable to suppose that course relations between the mathematics, physics, and mechanics can be much more intimate than is the case at present. Any suggestion that introductory courses in physics and chemistry might well be handled by a single department of analytical sciences will probably meet with derision, but from the standpoint of fundamental concepts and procedures there seems to be no valid excuse for the sharp demarcation exhibited by the separate sciences of physics and chemistry. It is another example of educational practice which has outlived its period of maximum usefulness.

The lecture-recitation method of teaching mathematics and mechanics has proved fairly satisfactory providing classes were not too large and, in the case of mathematics, will probably continue as the favorite method of instruction. The same cannot be said with respect to mechanics. The extensive literature on applied mechanics which has developed within the last two decades is an indication of the growing importance of this subject. Consequently a general revision of the engineering educational program must be

such as to make it possible for students to secure an even firmer and more comprehensive grasp of the fundamental principles of this subject. The experience of the German technical schools has shown that this can only be accomplished by the use of laboratories properly equipped and operated wherein the student can go from the lecture period to find out for himself the significance of such principles as the conservation of momentum and of energy, or that of least work. In the past we have copied from the Germans much of our educational system for engineers, but for some reason failed to realize the value of their applied mechanics laboratories as instruments of learning. As an afterthought, why shouldn't mechanics instruction be grouped with mathematics and physics in the single department of analytical sciences?

Turning now to the specialized engineering subjects which come in the third and fourth years of the engineering course, the problem of revamping and eliminating courses presents serious difficulties, particularly in the case of mechanical engineering and, to some extent, aviation. Regardless of the publicized statements of many of our more outstanding and enlightened industrial executives, personnel representatives from industry are anxious to secure engineering graduates of the type such as one would expect to be provided by technical institutes. Under the S.P.E.E. program, graduates of engineering courses will not possess the vocational aptitudes or knowledge which characterizes graduates of technical institutes. Present machine design courses which are too closely wedded to the empirical approach of contemporary industrial practice must be reoriented to emphasize the scientific aspects of the subject. Machine design textbooks now in use are an abomination in the sight of all good engineers, and no effective machine design course can be projected where the current type of text will be used.

Courses in theoretical and applied thermodynamics are under suspicion. Experienced instructors realize that very few students seem able to secure even a limited understanding of the first and second laws of thermodynamics. The caliber of prevailing courses in the subject is well exemplified by the very elementary texts which seem to be in wide use. The writer knows of but a single text on the market today which he believes is suited to an honest-to-goodness course in theoretical engineering thermodynamics, and to date the volume in question is just so much window dressing for the publishers. Under existing conditions of student preparation and the methods of instruction used it is not feasible to approach the subject of thermodynamics in a really logical and fundamental manner.

There are good reasons for believing that closer relationship between the physics, chemistry, and mechanical engineering departments will be of benefit to courses in thermodynamics. Such relations have been of the slightest in the past, and it is not easy to make them more intimate. The physics instructor is trained to be a researcher in the field of the pure sciences, and therefore possesses a different outlook on the subject of thermodynamics than the engineering teacher who is concerned with practical applications which have been unduly wedded to rule-of-thumb notions, and surprisingly lacking in analytical treatment. Thermodynamics, like mechanics, is a subject which is best handled with small lecture-discussion groups of students,

whose activities can be energized by the establishment of demonstration and experimental laboratories in the fundamentals of thermodynamics. Such a laboratory should not be confused with the standard type where code tests can be made on various forms of power equipment. The thermodynamics laboratory should be equipped with a variety of simple, ingeniously designed, and well-constructed models of apparatus which can be used by the student as a quick and efficient means of tearing aside the veil of obscurity which has for years shrouded the concepts of entropy and availability.

Other phases of the mechanical engineering course are equally in need of radical revision if attainment of the objectives of the S.P.E.E. reports are to be expected, but for lack of space cannot be discussed at this time. It is reasonable to suppose that curriculum changes are also desirable in the electrical, civil, and other engineering departments, but any remarks concerning these must be left in the hands of those specifically concerned with these areas of engineering education.

We have now come to the humanistic-social studies which will be common for all the engineering groups and carried on throughout the entire duration of the academic years. It is this portion of the new engineering curricula which presents in some respects the most interesting and yet problematical aspect of the new venture. Steps which have already been taken by some institutions to establish humanistic-social studies are an interesting exposition of the powerful and far-reaching influence of business and industry on the solution of our educational problems. Are we correct in suspecting that this influence is not always as sensitive to human values as we would like?

The first educational institution to establish a full-fledged humanistic-social division is the Carnegie Institute of Technology. This program has been discussed by Glen U. Cleeton,* Director of the Division of Humanistic and Social Studies. It is a well-developed sequence of subjects and closely parallels the suggested objectives of the S.P.E.E. Three classroom hours per week throughout the first semester of the freshman college year are utilized to provide the students with a historical background stressing the evolution of the present machine age. An equal amount of time is given to a survey of language, the arts, methods of thinking, etc., viewed as intellectual tools. The sophomore year is given over to problems of population and natural resources. Text material for both years has been carefully selected from the most authoritative of current publications and incorporated into textbook form for student use. During the junior and senior years the program is given a measure of flexibility by providing for electives. Social control, social economy, social ideas and attitudes, social aspects of the creative arts, seminars and projects represent the main avenues of study for these upper years. The successful operation of such a program really demands a specially trained faculty, but such is not available anywhere at this time. Lacking this kind of instructional help, it perforce becomes necessary to utilize staff members trained in the special fields of history, literature, languages, economics, philosophy, psychology, and engineering. No one can ask for a

* See October 1944, JOURNAL OF ENGINEERING EDUCATION.

more varied cultural background than this for launching a new venture in the study and teaching of human relations. But such diversity of training means anything but unity of viewpoint when dealing with the mass of human ideas which compose the framework and structural matter of the entire social relations program.

Engineers, economists, and probably psychologists are by training and experience more oriented toward a practical, utilitarian outlook on life, while the teachers of languages, literature, history and philosophy are equally inclined to interpret events from a more idealistic viewpoint. The contrasts of presentation can be sufficiently sharp to attract the students' attention, and create an uncertainty and confusion in the latters' minds very difficult to erase. A decided brake on the progress of the program can be the lack of time available to the student for thinking through the many interesting but conflicting statements and theories which are the very essence of this domain of study. The lecture method of instruction associated with the use of suitably prepared texts is likely to be the only practicable way of handling the instructional work, although every one knows that really effective results can only be secured by group discussion and a great deal of library search for information. This latter method is of course particularly desirable for the final years of the social relations study.

The objectives of the proposed S.P.E.E. humanistic-social division set a high standard of accomplishment. These objectives are of sufficient importance to stand repetition:

"1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.
3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
4. Acquaintance with some of the great masterpieces of literature and understanding of their setting in and influence on civilization.
5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with public welfare, and to a sound professional attitude.
6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study."

A comparison of the Carnegie Institute of Technology social relations program with the S.P.E.E. objectives listed for such a program can only lead one to the belief that such a program will probably not achieve the desired goal for some time to come. Objective (1) of the S.P.E.E. list seems within reach, but numbers (2) and (3), which are closely related and of very great importance, will be extremely difficult. In the limited time at his disposal a student cannot possibly do the amount of studying, plus compositional effort, which is necessary for the development of ability to read and write with intelligence and discrimination, unless this objective is considered sufficiently important to be

a feature of all his courses. No small portion of the S.P.E.E. publications have been devoted to wailings about the engineering students' marked inability to write good English. There is no good reason to suppose any better results will be obtained in the future, under any educational program, unless this problem of oral and written English is placed directly on the shoulders of every single faculty member as an important part of his instructional duties. Objectives (4) and (6) should be achieved without much trouble, but objective (5), like (2) and (3), cannot be acquired without a great deal of well-guided and energetic thinking on the part of the student.

Problems involving human relationships are much more complicated than anything the engineer will ever contend with in the applied sciences, and yet there has been so far a pretty complete failure to impress this on the students' minds. The seriousness of the situation in part carries back into the home and public school environments. In spite of careful selection of entering students, student thought is still saturated with the "Romanticism" which envelops and circulates through our national educational system. The tragedy of the matter is that boys with mental endowments of a high order only yield to the educational process under severe pressure. Over-emphasis of the importance of personality attributes, associated with the belief that "mental power" is the mark of a "high-brow," is a marked characteristic of our American mentality. The bad mental habits of a student's life-time must be broken before he can be brought to the point of accepting mental struggle as the natural and only road toward worth-while achievement.

As a closure to my rather haphazard remarks, I should again like to call attention to item (5) of the S.P.E.E. objectives. Today as never before our people are badly muddled when dealing with the questions of standards of morality, ethics, religion, and as a consequence of education. Fashion and propaganda becloud the mind and the average person unconsciously assumes the status of uncritical acceptance of whatever seems the prevailing trend of public opinion. If I am correct in this view, then it would certainly seem advisable to stress throughout the social-relations program all matters which are of a moral or ethical character.

Author! Author!*

Some Random Thoughts on Ideal Technical Books and Their Authors

By E. P. HAMILTON

President, John Wiley & Sons, Inc.

I appreciate very much the honor you have accorded me in asking me to speak before the English Division of the S.P.E.E. I welcome the assignment because, as a former practicing engineer, I can appreciate the value of the kind of writing instruction you now give your students; and because, as a publisher of technical and scientific books, I am convinced that the more thorough your teaching, the better will be the reports, the journal articles, and the books which the engineers of the future will write. Over the years I have had the good fortune to know hundreds of authors who in unguarded moments have told me a great deal about themselves and their writing problems. Out of all this I have formed certain opinions about authors, books, and writing which teachers of English will perhaps find interesting, if not particularly new or instructive.

I have chosen a subtitle for this paper which includes a discussion of the ideal technical book. I do this deliberately; I know I am on safe ground for the simple reason that the ideal technical book has not yet been published, and certainly the ideal technical book has not yet been written. According to the dictionary nearest at hand, ideal is defined as "That which is taken as a standard of excellence or an ultimate object of attainment, model, type"—and here is the part that impresses me most: "that which exists only in imagination"—so whatever I have to say from this point on should be interpreted as coming only from the imagination. By that I mean that there are no ideal manuscripts, no ideal authors, no ideal publishers, for we are all human folks and subject to all the frailties and limitations of our common mortality.

But the fact that the ideal exists only in the imagination should not deter us from attempting to realize our ideals. There are certain characteristics of authors and publishers which I should like to bring to your attention, and I do so with the understanding that I speak here only from my own point of view, which may or may not be in agreement with that of other publishers of technical books.

For the sake of the discussion, let us divide technical books into textbooks and books of reference. There is no important reason for doing so, since the main characteristics of a good technical book should hold for the reference book as well as for the textbook. There are those who believe that a good textbook

* Delivered at the 52nd annual meeting, S.P.E.E. (English), Cincinnati, Ohio, June 22-24, 1944.

is in a special category of its own, and takes much more skill to write than does a non-textbook. Perhaps we think so, too, but I can tell you that we are profoundly impressed with good work—whether the end result be called a textbook or a book of reference.

Well—what is a good textbook, or rather, what is an ideal textbook which is to be used as the basic book for class instruction? I could select representative textbooks from the lists of technical publishers and each one of them could serve as a model or type (as the dictionary definition has it) for the characteristics which distinguish them from commonplace or mediocre products.

To say that a textbook must be well written sounds like the ultimate in triteness. But a really well-written textbook is not so common as one would suppose. This is not intended as a disparagement of the many good and useful books that have been published in all the various fields of human knowledge. Remember, we are talking of the ideal. You teachers of English will know what I mean and you must frequently deplore, as most publishers do, the vast number of books constantly being turned out by the presses, which under no conceivable standard could be termed well written.

A textbook, in the very nature of things, is designed for students. Its first requisite, therefore, should be its teachability. The author should have constantly before his mind's eye the needs of those for whom it is written. More than one author has confessed that he was trying not so much to teach as to impress his colleagues. The poor student was ignored, if not forgotten. There is much merit to privately issued mimeographed editions, tried out with several classes of students to eliminate inconsistencies, faulty definitions, poorly thought-out problems, and many such weaknesses which prevent a textbook from becoming a valuable and inspiring tool of education.

Take the matter of definitions. Every textbook must have them. But all textbooks in a given subject for the same course will not be equally good in defining terms. Some will be wordy and vague; others short and inadequate. The good definition is exact, clear, and to the point, with all words omitted that do not contribute directly to the clarity of the exposition.

Here I am reminded of the late A. T. Quiller-Couch's scorn of the use of what he calls "jargon." The "jargoneer," he tells us, prefers the abstract to the concrete, the general to the particular, and the vague to the definite. Most of us, I am afraid, indulge in "jargon" habitually without being aware of it. Authors, we know, have their special "jargon," but whatever the brand, it most certainly cannot be called essential to good writing.

Simplicity or directness is an essential characteristic of any technical book. The author of that often witty booklet "Suggestions to Authors," issued by the United States Geological Survey, has much fun with writers on the subject of "stilted and showy writing." He mentions that even some of their older writers "prefer the long and the wrong word" and that many of the younger writers seem to "forget their naturally easy and simple ways of speech when they sit down to write a report, the change in their mode of expression being similar to that wrought by love in a young man as described by Benedick in 'Much Ado about Nothing':

" 'He was wont to speak plain and to the purpose, like an honest man and a soldier, but now he is turned orthographer; his words are a very fantastical banquet, just like so many strange dishes.' "

What I have said about the writing of good definitions applies, of course, to all phases of textbook writing—the presentation of theory, the writing of illustrative examples, summaries, exercises, problems, and so on.

Good writing is an important consideration but, after all, there are other major characteristics of the ideal textbook. We like a textbook to have many illustrative examples. This is good pedagogy, and if the examples are selected carefully the student more likely will understand the theory behind them. As a corollary to this, an abundance of well-graded problems, those requiring a thorough mastery of the subject, should be included in the book. Some authors like to include answers to every other problem, with a separate sheet listing the answers to the remainder. Others insist that the student have no access to printed answers, claiming that the modern student has his own methods, however irregular, of obtaining the correct answers to textbook problems.

Some of the best textbooks with which we are acquainted have a summary of important material at the end of each chapter. In these days of many digests, these summaries serve as a model for students who are unfamiliar with this valuable learning technique.

I admit to an enthusiasm for questions, as well as problems, to accompany each chapter in a textbook. They afford a sure test of the student's mastery of the subject matter. The other day, when I was reading one of our textbooks in geography, I had convincing proof of the necessity for good questions. I read along easily and quickly, much impressed with the author's argument. I thought that I understood everything thoroughly until I tried to answer some of the many thought-provoking questions appended for study and discussion. Much to my chargin, I discovered that I had to reread several sections of the chapter in order to answer the questions to my own satisfaction. This is probably a familiar experience, and a determining pedagogical reason for the inclusion of an adequate number of the right kind of questions.

The ideal textbook possesses excellence in what many consider minor matters, but which, added up, make for a good book or a mediocre one. We have all known instances of textbooks which used a nomenclature with only a scattering of advocates. Here, of course, is an opportunity to wage a grand battle between the devotees of one school of thought and the other—and what bitter battles they can become! A safe rule, perhaps, is to employ the nomenclature favored by a generous majority of potential users. All rules should be broken on occasion, and battlers for a new nomenclature know best when their innovations have a reasonable chance of success.

In scientific and technical books, particularly those used in classes taking up a new subject, we think a glossary a highly useful teaching aid. Much time can be saved for the student, who must constantly refresh his memory of new terms, if he can turn quickly to a well-prepared glossary.

A discussion of the index as an integral part of a textbook or a book of reference really should be left to a librarian, who can list, in chapter and

verse, all the sins of the careless maker of indexes. No one has to argue in favor of an index, but every publisher is forever in search of an index which covers adequately the subject matter of the book. That may mean an index of a few pages or as many as sixty-four pages. We have watched college professors thumbing through the pages of a new book, and inevitably after a moment or two they will turn to the index to look up a favorite topic. The book may have material on that topic, but if it is not listed in the index, you can imagine easily what those teachers will think of the book from this first casual examination. But one warning is in order, I think. An index is not a dictionary of words; it is a detailed guide to the contents of the book.

You will note that I am not adhering to a logical order of topics in this talk. I take refuge in the subtitle which says, "Some Random Thoughts on Ideal Technical Books and Their Authors." That is why I can say now, quite properly, a few words about the preface to a book. Perhaps this is the true order, anyway—since the preface is likely to be written last by authors who look upon it as "just one of those things." I must confess that I take a more than ordinary interest in the preface. I derive considerable pleasure from one that is carefully and thoughtfully prepared.

A good preface is actually an essay in which the author tells his prospective readers what he is trying to do, and his hopes for the book. The preface gives the author an opportunity, nowhere else offered, to summarize his philosophy of teaching and to present his over-all view of the field covered by the book.

I must not dwell too much on this matter in these days of paper scarcity. To be truly realistic, I should tell you that while the paper shortage is on, perhaps a preface taking a page of type is adequate for all ordinary purposes. Seriously, for your own interest, take careful note of the prefaces to books. In my years as a publisher I can recall only a few memorable prefaces. In my opinion the ideal textbook should have a memorable preface.

We must not forget to add a postscript, if I may call it that, on the subject of dedications. I insist (here I am peremptory again) that the ideal book, whether technical or any other type, should have the perfect dedication. Some of them are epitaphs, not dedications. Some, may I whisper, are even bribes to abused wives who have suffered much during the gestation and borning period. You know this dedication:

"To H. M. K.
without whose constant devotion
and unstinted help this book would
never have been written."

We like the realism of this one—which never got into print:

"To Lavinia
My infant daughter, whose nightly
wailing kept me sufficiently awake to
finish a disagreeable task assigned me
by a persuasive publisher."

A more sobering dedication, but a perfect one of its kind, is this one which we ran across recently in a Wiley book:

"To Our Parents,
Ourselves and
Our Children
As we walk the war-road to Peace."

Most of the virtues I have mentioned as inherent in the ideal textbook apply as well to the reference book. There is little justification for making any

distinction between the two types of book, but for purposes of classification I suppose it is necessary. All books of information are used for instruction purposes, but the so-called reference book omits many of the teaching aids which we look for in a textbook—exercises, problems, summaries, answers, and so on.

But there is an ideal reference book, too. It would be pleasant to pick up a book in this category without finding in the first chapter an historical section going back to the days of the Phœnicians. The subject of the book may be ice cream, bridges, machine design, or what not, but that usually useless and irrelevant historical material is there, and sometimes, unfortunately, to the extent of forty to sixty pages. Then there is likely to be another section summarizing fundamental or related material already available in dozens of books. Even in times of paper abundance there is rarely an excuse for such detailed treatment.

Here we can learn something from the English. I have been impressed in recent years with the skill with which they have handled monograph material. Their books in the engineering field particularly have been well prepared, containing the type of information from which the busy engineer can derive immediate profit. From our point of view, the only serious defect in these English monographs is their almost complete disregard of American practice.

It is dangerous, however, to be too arbitrary in our generalizations, for tomorrow we, or some other publisher, may issue a reference book which will have all the above faults, but which still may have the data which research men and other engineers will be glad to have, even without the label "the ideal technical book."

From some of my earlier remarks you may have come to the conclusion that, if books were prepared according to a formula based on the considerations mentioned, success would inevitably result. Alas! This is not true. A book can be well written, accurate; it can possess in full measure all the known teaching aids—and it still will be received with apathy. We like to think that the deciding factor lies in some inner vitality of the book which literary folk probably call style. In a race horse it is class; in an athlete, form; in a human being, personality. Whatever it is, it is the distinguishing virtue in the truly successful book.

A great deal of nonsense has been written about book design and format. To me there is nothing mysterious about an attractive book. If you start out with the fundamental notion that a book is designed primarily to be read, you can't go too far astray in design. It is also assumed that you use good materials, and that you employ a competent printer and binder. It is likewise taken for granted that the person responsible for design has some idea of how a scientist thinks and works.

In a technical book we are limited in our choice of type faces, because few fonts have the mathematical symbols that are necessary to do the job. The first consideration is the selection of a clear, legible type face. Now this sounds simple, until people start telling us what is clear and what is not clear. Over the years, however, one or two faces have evolved that are capable of presenting scientific and technical material so that it can be read with ease.

A good designer can do wonders

with margins, and with the harmonious arrangement of headings—side, center, chapter, and page. He also knows how to make formulas and tabular matter stand out clearly and æsthetically. He knows how to use bold face judiciously and effectively. He also knows how to handle illustrations so that they mean something. He knows, for instance, that a line cut can illustrate a principle much more effectively than a halftone, however beautiful the halftone may be.

There is an art, too, in the designing of a beautiful but appropriate title page and the lettering for the front cover or shelf back of the binding.

And when the finished book is ready and is examined by our ideal publisher (and there aren't any, of course), seldom is he completely satisfied with the results. The general verdict may be that it is a beautiful volume, but that he knows literally dozens of places where improvement could be made—and so on, ad infinitum.

So far in my talk I have hinted only barely that in addition to an ideal technical book, there might be a phenomenon which we might label the ideal author. I do not know whether it is discreet to come right out in the open and dissect for general observation this rare creature. We are dealing always with faulty human beings, but it might be fun, nevertheless, to see the kind of author we should like to have on our list if it were possible to arrange such matters.

The ideal author should be a composite character, many men in one—a sort of Admirable Crichton. He should have the teaching ability of Mark Hopkins, the engineering genius of Steinmetz, the writing talent of William Hazlitt, the eloquence of Henry Ward Beecher, the all-around wizardry of Franklin. And to top it off, he ought to be able, perhaps, to play golf like Bobby Jones at his best. What a fellow he would be!

The ideal author presents to his publisher a clear, perfect manuscript, beautifully typed, with all headings plainly identified. He has been over it again and again, so that there is little work for the editors to do. There are no misspellings, no impossible punctuation, no grammatical mistakes. All abbreviations are standard and consistent. Full and complete directions are noted for the printer. His illustrations are filed in order, each with the proper number, and with croppings and sizes indicated. There are, heaven help us, no superfluous or useless illustrations; all are definitely relevant and in excellent condition for reproduction.

Our ideal author accepts graciously and gratefully the voluminous instructions on how he is to handle his part of the work as the manuscript goes through the various processes. He reads proof conscientiously and promptly. Never does he change his mind about the wording of a definition or the explanation of the theory underlying a new gadget. He never would be guilty of changing his system of abbreviation. In effect, he makes no changes except to correct compositor's errors, and the rumor is abroad that occasionally, after much searching, a few of these may be found.

The ideal author does not pretend to expertness in book design after a reading of the publisher's book of instructions and a primer on typography. He does not insist on the use of Cheltenham as a text type only because his marriage license was thus set. He does not demand that the printer use bold face and italics liberally all through the text for reasons of emphasis. No, the

ideal author is content to let the publisher take over all these perplexing problems because he has men trained to do these jobs well.

The ideal author never sets himself up as a specialist in book marketing. He is modest about his ability as a creator of sound advertising copy. Rather he is persuaded that the publisher has remained solvent over a period of years because he knows markets and the type of advertising copy that will sell books. Somehow our ideal author will get the overwhelming conviction that the publisher wants to sell his book as much as he wants to see it sold.

A question often asked is, "Do present-day authors of technical books write as well as did those of previous generations?" This question cannot be answered categorically. For one thing, these authors of older days grew up in a period free of such present-day attractions or distractions as funnies, movies and radios, when about all left to do on long winter evenings was to study or read the substantial books the old folks left around. Also, today there are hundreds of authors of technical books rather than dozens, as in the older days. Furthermore, in the past the writing of technical textbooks seems to have been left to a relatively few big names, such as Thurston, DeVolson Wood, DuBois, Merriman, Lanza, J. B. Johnson, and Peabody.

With a view to seeking at least a partial answer to the above question, I recently asked our senior editor to look through some of our earlier books beginning with Schoolcraft's "A View of the Lead Mines of Missouri" (1819), Davies' "Elements of Surveying" (1839) (the West Point textbook), Mahan's "Civil Engineering" (1868), and some of the books by the writers mentioned above which were published in the latter part of the last century. She makes this interesting statement:

"I believe that the generalization is safe that the writers of our technical books of the last century had a more fluent and easier style than our writers of today. At least the ones listed above understood the elements of sentence structure; their meticulous punctuation demonstrates that they had a real grasp of the grammatical framework of their sentences. They could even handle participles correctly.

"On the whole, they wrote as one might expect intelligent, well-read men of good general background to write. I mean by that statement that their background was wide enough to embrace other languages (French and German quotations appear with some frequency, and Merriman has a Latin motto on the title page of his "Textbook on Retaining Walls and Masonry Dams"), and frequently they indicate philosophical sidelights or see their subjects in true perspective. They usually start with definitions and announce the limits of the subjects that they intend to discuss, applying the sound pedagogical principle of building on a foundation of the known and proceeding to the unknown. They successfully avoid "jargon," writing simply, directly, and with considerable facility. In short, they handle English like ordinarily well-educated men rather than as specialists.

"All this sounds uniformly favorable; it should not be taken for granted that their productions were perfect. In general, they show complete disregard for many details about which we take tremendous pains today. They have no system of nomenclature or consistent scheme for abbreviations, and they exhibit such reprehensible habits as using Arabic and Roman numerals in the same numeration."

But even though there may have been more style in the writings of authors of older days, I think it cannot be denied that the average technical

book today is better than the older books, more teachable and more generally useful. The authors obviously are responsible for most of the improvement, but the publisher, too, can claim some small amount of credit. Over the years he has learned many valuable lessons—most of them by painful experience. These he places at the disposal of his authors, to be accepted or rejected according to their pleasure.

But what of the ideal publisher? Is he a paragon of many virtues—this person who demands so much from his authors? Perhaps our definition should be left to a committee of authors but, lacking that, let us see what sort of man our ideal author is reasonably entitled to expect. The ideal technical publisher, too, should be a man of parts—intellectually he should be at least a civil, electrical, mechanical, chemical, and metallurgical engineer rolled into one. Perhaps he ought to be a moderately capable physicist and mathematician. Since he publishes many books in the sciences for liberal arts colleges, should we not demand also that he measure up to the educated man as described by Dr. Nicholas Murray Butler in those well-known lines which begin, "These are evidences of an education," et cetera?

If this composite picture of omniscience is not possible of attainment—and let me be the first to say that it isn't—what are some of the attainable characteristics of our ideal publisher? To begin with, he must be an enthusiastic listener. He should be prepared to spend hours becoming acquainted with the origin, development, and final preparation of each manuscript. He should be an expert in the art of cross-examination, to make sure that every phase of the project is covered in detail and thoroughly understood. Several times during the conversation, the publisher will intrude with that sentence known to and expected by every author, "No, I'm afraid you can't do that." It usually occurs when there is a request for six or eight four-color inserts.

The publisher—we are talking still of that mythical person—must be a person of "sweet reasonableness." If the author says his manuscript will be ready on September first, the publisher should not be annoyed unduly if the manuscript arrives the following April, and with most of the illustrations missing. When the manuscript, in the course of time, goes to the printer and the galleys start rolling, the publisher's temperature should not rise to fever height if the book is rewritten there and then, causing an excess of the allowance for author's alterations. Of course not! Isn't the author a novice at such things and therefore not subject to such ridiculous rulings? The changes he made were important and improved the book tremendously. The publisher wants a superior book, doesn't he?

To drop the facetious note, the true publisher believes heartily in his authors; he has confidence in their ability and shows it by keeping the book before the public year after year. I refer, of course, to the standard book, the kind of publication which every publisher wants. This type of book will stay on his list, he hopes, for twenty, thirty, or even forty years, and if it reaches one hundred years, as one Wiley book did this year, well, that is the publisher's idea of a genuine publishing achievement. Barabbas was a publisher, we are told—but he was an exception to prove that publishing is an honorable calling. Worthily conducted, it can be a great influence for

scientific advancement and for the development of new and promising talent; and the relationship between authors and publishers can be, and usually is, a partnership characterized by mutual respect and friendship and motivated by loyalty to scholarship and the furtherance of useful knowledge.

There is every reason to believe that the engineering colleges of our country will continue to graduate men who will become the great engineers of the future. They will build colossal dams and aqueducts, countless thousands of miles of concrete highways; they will design bridges spanning huge waterways; they will create giant turbines and other great machines; they will plan, erect, equip, and coördinate the facilities of mammoth chemical and processing plants; they will bring into existence myriads of useful products fashioned from new materials with much skill and beauty. These are only some of the splendid achievements we shall expect from our technical men. But if the knowledge which they have gained of forces and materials is to be transmitted to new generations, proficiency in the use of language must also become an important part of the engineer's professional equipment. I am sure you have said these words to your students many, many times. I repeat them because we, as technical book publishers, realize that our future publications are dependent upon your success in training men who are capable writers as well as competent engineers.

To you teachers of English I therefore say: Engineering students need all your patience, your sympathetic understanding, and your wise counsel. Occasionally, I know, you are discouraged, for there are moments when it must seem that there is little use in attempting to teach writing to students who are absorbed chiefly in mathematics, physics, and chemistry. But I also know that your efforts are worth while and tremendously important, not only to the student and to his future employer, but also to the permanent enrichment of contemporary engineering literature. Yours is a great responsibility and a magnificent opportunity.

S.P.E.E. and E.C.P.D. Initiate Coöperation in Professional Development

By IVAN C. CRAWFORD
Chairman, S.P.E.E. Committee
and
CHAS. F. SCOTT
Chairman, E.C.P.D. Committee

Robert E. Doherty, retiring Chairman of the Engineers' Council for Professional Development, in October, 1943, said "The Committee on Professional Recognition has followed with unremitting energy its policy to continue an educational campaign among the new generation of engineers that would lead ultimately toward the end of a 'greater solidarity of the profession.' Professor Scott's committee is carrying out its purpose largely by the distribution of appropriate articles such as Dr. Wickenden's 'Second Mile' and now plans are being framed jointly by the E.C.P.D. Committee on Professional Recognition and the S.P.E.E. Committee on Personal Development, of which Dean Ivan C. Crawford is chairman, to give even greater emphasis to the enterprise." The principal joint activities of the past year are here recounted:

THE PRESIDENT CALLS FOR ACTION

1. President Doherty, in his dual capacity as President of S.P.E.E. and Chairman of E.C.P.D., in the fall of 1943, was requested to initiate the joint program of the committees of the two organizations. In a letter to each engineering teacher he stated "Your position and opportunity are unique. Among the fifty groups of S.P.E.E. in its 50th year none was authorized to deal with engineering as a profession. We are starting something. It needs the acceleration which your views and convictions can give." (Letter published in the November 1943 JOURNAL OF ENGINEERING EDUCATION.) His clarion call was unprecedented. It was no perfunctory letter. It seethed with a conviction which again animated his address as retiring President of the S.P.E.E. in Cincninati in June. The letter must be re-read for full understanding—it tells what the engineering teacher may do to build the profession. "His responsibility is very great and his opportunity for service to his profession and to his country is most challenging."

WHAT IS E.C.P.D. TRYING TO DO?

2. The report of the E.C.P.D. Committee on Professional Recognition was sent by Dean Crawford to S.P.E.E. members. "The objectives of E.C.P.D. can never be achieved if only the members of the Council know what E.C.P.D. is and what it is trying to do. Individual engineers must know and be interested in these activities." To achieve the objectives of our joint program, engineering teachers should know E.C.P.D. The report tells the story of the evolution of E.C.P.D., of the incidents which led up to a plan for joint action culminating in E.C.

P.D.; its immediate objective, the development of the young engineer which was delegated to four committees; and its general objective, the enhancement of the professional status of the engineer through "greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems." The report tells why the Committee on Professional Recognition is concerned with "the new generation of engineers" and how the original "Second Mile" proved an effective implement; also how our S.P.E.E. coöperation came about, and concludes with a dissertation on How to Help as a sequel to E.C.P.D.'s general plea, Will You Help?

Key Positions of Society Counselors

3. To Faculty Sponsors of student organizations of the national societies the following letter, signed by the two Chairmen, was forwarded with a letter of transmittal by the heads of student activities in the several societies:

As chairmen of coöperating committees of E.C.P.D. and S.P.E.E. for promoting professional development we desire to work with you in planning to give it new emphasis in "Engineering Education after the War."

Dr. Doherty in his keynote letter indicates the lack of professional consciousness and coöperation among engineers. He calls upon the members of S.P.E.E. "to take a stronger part in building the engineering profession; . . . if the engineering profession is to come into its own with a new understanding of its inevitable responsibility to society, the engineering teacher must bring it there."

We feel that you as representative of a national engineering society as well as a faculty member are in a unique position with double opportunity and responsibility.

We are therefore suggesting that you —and there are some 500 of you—join in the general planning for "Engineering Education after the War" by crystallizing your best thought as to methods for making the student branch more effective in promoting professional consciousness and an understanding of the place of engineering in modern life. *Your student organization presents a fertile field for cultivating "professional development."* There are several reasons.

Student affiliation with a national society gives at once a realistic introduction to the profession and a real sense of belonging to it.

From Society contacts come appreciation of the kind of practical problems that will come later and the preparation needed; problems not only technical but ethical and professional.

The forward looking student will sense the non-technical aspects of his profession and the role engineering should play in a better world order; youthful imagination may vision his part in it; such may be the beginning of the future leader.

The student society by its method induces interest and initiative. Here the student is not told what to do; he can do what he wants to do—make his own program, choose his own topics, handle his own discussions, select speakers. He relishes a bit of "free enterprise," free from scheduled regimentation.

Adroit counseling may indicate regions to be explored under the student's own motive power of interest and inquiry. The development of "independent activity" is a goal of education.

The recommendation of the five society presidents for joint student meetings during the present emergency may be followed in principle in making plans for the afterwar program. The several counselors at an institution may act jointly on their common problem, you may compare and evaluate past experiences (for example, in the use of "The Second Mile," or the adequacy of outside speakers) and formulate your ideas

as to objectives and methods as a basis for future plans. Discussion with faculty colleagues and graduates, and with practicing engineers and members of your Societies may be helpful.

It may be found wise to continue joint meetings of student groups to deal with the common problems of their profession, incidentally preparing for the solidarity so essential later on.

The present need in the evolution of engineering as a profession is professional understanding, consciousness, solidarity and joint action. The rich opportunity for cultivating these qualities in the student branch surely puts the counselor in a "Key position. His responsibility is very great and his opportunity most challenging."

We offer our assistance as an initial clearing house that your best thought and proposals may be made available to each of you in a summary which may have fruitful and far reaching results. We propose close coöperation with your national student committees, which handle all phases of your work, while we are concerned with the professional aspect. Please send your comments and suggestions to the S.P.E.E. chairman, with copies to the E.C.P.D. chairman and to your national society chairman.

First Conference: A New Committee

4. On the general program of the S.P.E.E. convention we recommended papers in view of the emphasis laid on the responsibility of the engineering teacher for building the engineering profession. Our recommendation arrived too late for inclusion in the general program and Secretary Bishop suggested that we arrange a conference which we did. We invited deans and faculty counsellors to discuss Vice-President Gilkey's notable March editorial, A Profession Without Unity. This conference formally devoted to the "profession" was a veritable experience meeting. Most of the speakers told how they present the engineering scene to their students, but more significant than what they said was their keen interest and pride in the solutions they had found. There are over 25 written contributions, the essence of which it is planned to make available later.

At the conclusion of the conference a resolution was passed asking the Council of S.P.E.E. to appoint a committee (one not having other duties) and thus to put on a permanent basis what has been somewhat of a pioneering project. President Rogers has appointed the following Committee on Professional Development: Ivan C. Crawford, *Chairman,* F. M. Feiker, H. J. Gilkey and R. W. Warner. Dean Steinberg, who proposed the resolution, says, "I am of the opinion that this session started something that will prove of great value to engineering students and to the profession."

"The Engineering Profession Tommorrow"

5. The Engineering Profession Tomorrow was not specifically planned by the coöperating chairmen though it more than meets their expectations when they asked that the profession have a place on the general program. President Doherty has closed his year with a fine sequel to his keynote letter at its beginning. It is no perfunctory address. It is distilled from his experience with engineers and with engineering bodies. It begins, "The engineering profession tomorrow will be largely what engineering education today makes it." He tells what the profession of today is not and what it ought to be; he says that the primary

end of education is "intellectual power, not merely routine skills and memorized facts," and in his last paragraph, in the September 1944 JOURNAL, is this "and the coöperation of E.C.P.D. and S.P.E.E. committees according to a definite plan approved by both bodies affords the means for developing professional interest and understanding." (His interest in the proposed coöperation led him a year ago to make a special E.C.P.D. fund available for its early activities.)

WICKENDEN'S "RE-SURVEY"

6. The Second Mile—A Re-Survey was announced and an order slip enclosed in Dean Crawford's letter to S.P.E.E. members. The advisability of issuing the revision now had been questioned, students were disappearing from schools, people were engaged in war effort, the publication of the original in society publications two years ago and the subsequent distribution of 20,000 copies suggested a satisfied demand. Nevertheless, 5,000 copies were ordered. The early circulation had not satisfied the demand; it created it. More of the "Re-Survey" have been sold in a few months than of the early edition in two years. Over 50 schools have ordered from 100 to 900 and nearly two score industries and societies have taken an average of about 300.

True, engineering is gaining in esteem and popularity due to the war effort; older engineers are trying to orient themselves; they are trying to locate the dividing line between professional and unionized groups; they are trying to visualize and realize the United Front which they now lack. But why the orders for the new version of "The Second Mile?" We asked larger purchasers "Just why did you order the new pamphlet? for whom? how do you use it? "Not a questionnaire but a sort of Gallup poll which may indicate the status of "professional" interest amid the present confusion. In the lines and between the lines of the replies there is a serious, not merely casual, interest and a readiness, even a missionary zeal, to spread the Wickenden gospel. In the schools it is found to have vitamins for all, from freshman to president. Replies must be condensed. Two deans are liberally quoted; then a composite is assembled; then follows a culling of pertinent sentences:

WHERE "THE SECOND MILE" GOES

"1. Copies of 'The Second Mile' ordered for faculty members and for seniors. 2. The importance of what Wickenden calls 'The Second Mile' cannot be overemphasized. 3. In the difficult post-war years ahead of us, it will be highly essential that engineers hold fast to professional ideals of unselfish service, of technical competence, and of broad interest in all that concerns human welfare."

"A copy to each of my students (to develop the professional attitude even if they should only have a career as technologists); initiates of Sigma Tau and Tau Beta Pi; also to the president of the University, the engineering faculty and to members of one or two of the general committee of the University. I hope that my colleagues have an understanding of what a professional engineer is. What results do I get? I only wish that I knew. I am enthusiastic about the pamphlet and shall continue to use it."

For freshmen it is used in lecture and orientation courses; in assignments to be followed by questions; in a course in engineering development; in

English classes as an exhibit of English by an engineer; it is useful for its inspirational value creating a sense of pride in the profession and indicating its responsibilities; it lays the foundation of correct professional attitude early in the student's career; it makes the beginner aware of the service motive of the profession. Some are experimenting with methods of presentation and observing results; some expect one result from freshmen and another from seniors.

For more advanced students the pamphlet is the basis for a wide range of professional presentation and discussion. It is fertile material for student society meetings. "It served as a springboard for a student-faculty discussion on professional aspects of engineering and on the relation of our curriculum to these problems. It brought out vigorous questions and opinions from students and staff. 'Let's have more like that.'" "As required reading for discussion in our senior classes it has stimulated a great deal of interest and thought among our students. The reaction has been most favorable, which is particularly important in these uncertain times." "Starting with freshmen we expect to 'follow through' in the student branches to the development of an ethical consciousness, such as the development of a code that may be put into practice by the student body." "Students are so engrossed in a single objective, and teachers as well, that we have lost our sense of professional direction. Wickenden has helped our students find at least the beginning of the road."

A letter to graduates at their home addresses contained congratulations on graduation followed by "Will you choose some quiet moment to read this little pamphlet? When you have reread it and have time to meditate on it, please write me your reactions."

"My own interest in helping students was stimulated by receipt of the Report of the Committee on Professional Recognition, so I ordered 200 copies of the Re-survey."

"The work of E.C.P.D. is a bulwark of strength; it points out with clarity and persistence that professional recognition must come not through enforced demands but by self improvement, superior service, and a growing sense of public responsibility"

Reports from officers or personnel men in industry attested the favorable response to the distribution of the pamphlet among their engineers.

Recapitulation

It may be noted that the activities of the past year have been directed to the engineering teacher "to arouse his responsibility in promoting the non-technical phases of the make-up of the engineer and the qualities that contribute to the building of the profession." The attitude, interest and action attested by the conference at the convention and the avidity with which the new version of the Second Mile is being received show that educators are becoming alert to the problems of the profession. The recent S.P.E.E. report on Engineering Education After the War, published in the May Journal, states "Events have shown one major extension to be needed, namely, a more positive indoctrination in civic and professional responsibilities," and it devotes over half a page to Cultivation of the Ideals and Obligations of the Engineering Profession, focusing responsibility on engineering faculties.

Toward the end of his new section, Does an Engineer Need his Profession? Wickenden says, "Most of all

that has been set down above has an idealistic base"; Doherty calls for "Professional consciousness"; Gilkey for "Over-all esprit de corps"; the E.C.P.D. committee report for the "Spirit of the Engineer." That intangible *Something* is a reality which is essential to coöperation and a united front. Attempts at organized coöperation without it have failed. Ideals must be implanted in the young engineer and nurtured by the engineering teacher. Many teachers are of the opinion that the professional aspects of engineering "should be brought into all courses incidentally by the instructor."

Again, "The engineering profession tomorrow will be largely what engineering education today makes it."

Agricultural Engineering*

By J. BROWNLEE DAVIDSON

Head, Agricultural Engineering Department, Iowa State College

The background of experience from which I will address you for the next few minutes began forty years ago when a newly established position was offered to me by the University of Nebraska. The responsibility of the new position was to organize and give instruction in a new subject to be given the name of farm mechanics.

There were a number of considerations which favored the acceptance of the position outlined to me but the opportunity to make a contribution to the development of certain agricultural machines which I had dreamed of as a boy on the farm was one of the determining factors. As a prospective graduate I did not have a very clear idea of the scope and character of the work of the engineer or the possibilities of the service the engineer might render to agriculture. The outcome of the proposal was that I asked to be released from a position I had secured with a large manufacturer and the course of my life was changed.

At any rate, I am with you today to talk briefly about agricultural engineering, which grew out of this development in education, to tell of my personal adventure and that of 500 graduates who share with me their successes and achievements. I believe that it is expected that I should outline from my experience some of the ideas I have of the scope and character of agricultural engineering, to cite some of the accomplishments in this new branch of engineering, and to point out, if I am able, some of the opportunities for service and development in this field.

The Purpose of This Talk

It is the acknowledged purpose of my remarks to enlist the interest and secure the moral support of a larger group of S.P.E.E. members in a new branch of the engineering profession. I believe that the development of agricultural engineering is worthy of your assistance and encouragement. Although the record for agricultural engineering is one of accomplishment, it is felt that progress has not been made as rapidly as the circumstances justified. It is very much desired that engineering educators consider the possibilities in this branch of engineering and lend it support, as I believe opportunities fully warrant.

May I undertake to describe and define the field of agricultural engineering. In earlier years I would not have undertaken to do this, because I would have considered it unnecessary if not presumptuous. But nothing, I believe, will contribute more toward a meeting of minds than to start our thinking from a common and an accepted viewpoint. Even after these years I am

*Presented at the 52nd annual meeting, S.P.E.E. (Agricultural Engineering), Cincinnati, Ohio, June 22–25, 1944.

often asked, what is agricultural engineering? May we explore the field, and establish the areas of interest.

Agriculture Engineering Defined

Many of the conventional definitions for engineering include three central interests, described by three typical phrases: (1) the organization and direction of men; (2) the application of the forces of nature; and (3) the utilization of the materials of nature. In the accepted concept of engineering these three central interests are combined into a program for the production of commodities and services contributing to the well-being of man or the human race as the definitions may read. Using more common terms, these central interests of the engineer are *labor, power* and *materials.* We may expect that the general interests of an agricultural engineer are the same as other representatives of the engineering profession.

It is frequently pointed out, and I mention it in review for the purpose of building up a common approach, that engineering may be classified as to the character and nature of the engineering problems and techniques involved, such as civil engineering or mechanical engineering. But it is likewise a matter of precedent extending back over many years, to organize engineering about an industry, mining engineering being the oldest example. The first classification is in a sense a vertical division, while the latter is a horizontal division. Agricultural engineering is similar to mining engineering in that it is the engineering organized about an industry—about agriculture. I might outline and describe the distinctive branches of agricultural engineering which have developed: power and equipment, farm structures, and soil and water conservation. But it seems we should be concerned with the principal engineering interests as they are related in agriculture. Consider labor first. The engineer should be a specialist in labor efficiency. The 1940 U. S. census reports that 18.5 per cent of the persons gainfully occupied are in agriculture. The per cent for manufacturing of all kinds is 23.4 per cent, only one-fourth greater than that for agriculture. Those employed in transportation, communication, and utilities are 6.9 per cent of all, or a little over one-third of those in agriculture, while the per cent for mining is 2 per cent, or only one-ninth of the workers in agriculture.

Power

Let us next consider the use of power, or energy to be more exact. The 1940 census credits all manufacturing as using 21 million horse power in prime movers and 29 million horse power in purchased energy, or a total of 50 million horse power. It is necessary to resort to an estimate of the primary power used in agriculture. Such an estimate for 1940 is 97 million horse power. It is recognized, however, that the actual energy used in horse power hours by agriculture and the manufacturing industries may be quite different a matter.

Materials

As to materials, agriculture is an extensive user of materials of construction, though I am not able to make comparisons for you. However, the census indicates that the actual value of farm buildings is over 10 billion dollars, of which the replacement cost is thought to be about 30 billions. The farmer must not only house his family,

but his livestock, his crops and his equipment. Accepted data indicate that expenditures for farm structures has in the last decade varied from 140 to 900 million dollars and the purchase of farm equipment has varied from 300 to 700 million dollars.

Such is the agricultural engineer's stake in the three central interests of the engineer—labor, power and materials. But is there the opportunity to apply engineering methods and techniques to agriculture? Occasionally and less frequently than formerly, it is suggested that there is little room for the practice of engineering in agriculture. Let us consider just one illustration, the production of one crop. Iowa is in the center of the Cornbelt. The state, in 1943, grew eleven million acres of corn yielding a crop worth over 5 billions of dollars. The Iowa Agricultural Experiment Station has supported extensive engineering studies of corn production. What is the technique of producing corn? True, it is necessary to start with the best agronomic program available—the soil management program should be according to the most modern conception of the sciences involved—it is necessary to have the right kind of seed and be equipped with a knowledge of the culture of the corn plant. But the actual production of the crop, after all of these have been provided and arranged for, which consists in the preparation of the seedbed, the planting of the seed in the right amount to the right depth, the fight on weeds and finally the harvesting of the crop, is accomplished by labor and by power applied through machines—the emblems of the engineer's art. There are many considerations in the production of corn, but none are more important than the man hours of labor, the horsepower hours of energy, and the expenditure for equipment. Standards of performance are just as important here as in the factory. To state that under certain conditions, to produce an acre of corn, it requires four man hours of labor, 35 horsepower hours of power and an annual expenditure of one dollar per acre for the use of machines, rings just as true to the engineers as any data you may quote from any production enterprise.

It may be appropriate to consider briefly the special significance of the industry to which agricultural engineering is related. This is a matter of inspiration to the agricultural engineer and should be of some interest to all engineers. First it should be pointed out that agriculture is a primary industry in which all must be interested because agriculture supplies food and raw materials for food, shelter and clothing and these are elemental needs of all. The only other industries that approach agriculture in this respect are home making, the basis of civilization, and education, the task of transferring to the coming generation such knowledge and experience from the past as can be passed on.

So far, I have tried to point out something of the scope and nature of agricultural engineering. In addition, I would like to present three other matters for your consideration.

Agricultural Engineering is Exacting and Difficult

From time to time I meet engineers who go out of their way to explain that agricultural engineering is very elementary and stands much below the high standards for other branches of the engineering profession. Such men are in my opinion revealing a lack of an intimate knowledge of the engineer-

ing problems of agriculture. One of my particular interests is machine design, and I have met machine designers who are contemptuous of farm machines. In a few instances I know, men with these views have undertaken to show up the resourceful and ingenious farm equipment designer, only to find that they have overlooked the economic limitations as well as the condition of exposure and rough usage to which the machines are subject.

A few years ago an engineer with particularly fine training, including graduate work leading to a doctorate degree in addition to a conventional curriculum in engineering, and with extended experience in design, particularly centrifugal pumps and aeroplanes, was employed by a western institution to work on orchard heating problems. He has stated that although the first two lines of design were recognized as representing a rather high order of mechanical knowledge and skill, this new work was much more difficult. Not only were the usual design problems present but meteorological and biological relationships were involved. This has been the experience of many other engineers.

The division of agriculture into over six million units of farms with individual management means that engineering techniques must be introduced in a way applicable to the conditions to be met. Mining is organized into 12 thousand units or $\frac{1}{500}$ as many establishments. This does not mean that there is not the opportunity for engineering in agriculture, but that the problems are more difficult. To suggest that the engineering related to agriculture is so elementary as to be non-existent either indicates a lack of understanding of the genius of engineering or it reveals a complete absence of imagination. Where there is so much labor, power, and materials there must be an opportunity for the engineer, and his work may be as difficult if not more so than that of many other branches of the profession.

A Significant Advance

Although agricultural engineering has not made such progress as those in this branch of the profession would have liked, there are some developments and achievements that may be pointed to with a degree of pride. There has been much engineering progress in agriculture but the professional engineer has not made a large contribution. The proportion of manpower required in agriculture, the production of food—a basic need—has become progressively less as the years have passed. In 1840 the agricultural workers were 77.5 per cent of the total; in 1900, 35.7 per cent, and in 1940 only 18.5 per cent. Now after two years of war it is estimated that only 16.7 per cent of our manpower is used in agriculture. It would be presumptuous to claim that all of this change has been due to the introduction of engineering methods, for increase in yields from improved varieties, the influence of better soil management, and more effective crop protection have contributed much, but all careful observers will agree that increased labor efficiency was the most important factor.

The industrial progress in the United States has been the outstanding event of the world's industrial history. It is true that we had a wealth of resources in materials but it is also true that the manpower came largely from agriculture. Do not let anyone assume with full assurance that he is correct in believing that industrial development

came first and agricultural development followed. The reverse order of events may be as nearly accurate.

We are now engaged in a war that is testing our resources to the utmost. It is generally accepted that we have gained our present advantage through our ability to produce in quantity the equipment and munitions of war, but I would like also to remind you that no country in the wide world could spare so much manpower from its agriculture as the United States, and at the same time increase production. In my home state there are about 200,000 farms. These are individual farms—family farms with the largest annual income per farmer among the states. A recent estimate credits these farms with furnishing 190,000 men to the armed forces and to munitions manufacture. If we have the wit and wisdom to go forward after this war and continue to increase through engineering, our services and commodities to human society, additional manpower will be available from agriculture, because all of its prewar requirements will not be needed. But the particular point is that, largely through the application of engineering techniques, agriculture has made its contribution to the war effort.

Russia's National Defense

The Russian people have made a magnificent defense of their homeland. They have repelled the invader, our common enemy, and history may record that through them the world was saved from despotism.

All liberal minded observers will agree that this tremendous war effort upon the part of Russians had its genesis in the application of engineering technique to their agriculture,—the mechanization of their agriculture as they called it. Under the old regime in Russia about 85 per cent of their population was on the land. Very primitive methods prevailed and often there were famines. The other 15 per cent of the population were divided between the nobility, and those in commerce and in the trades. Those responsible for the first 5 year plan foresaw that if they were to develop industrially and otherwise, manpower had to be made available from their agriculture. So they embraced our agricultural methods—our more extensive methods, in fact. Some of us were glad to have a small part in the program in 1929. To be an engineer in Russia at that time was to command respect. To be an American engineer was to be esteemed, and to be an American agricultural engineer was to hold a place of special honor. It was out of this program of agricultural engineering the Russians secured the manpower for their manufacturing industries, for their transportation, their new educational program, and for their armed forces. When the story of Russia's war effort is properly written into the pages of history, the influence of the introduction of agricultural engineering must be given a prominent place as a background.

The Future

And now I would like to direct your attention to the future. It is the worthy ambition of the engineer to produce commodities which will contribute to human well-being, in other words, to make the world a better, a more comfortable, a more healthful and interesting place to live. To some of us the opportunity seems particularly inviting to the agricultural engineer. The possibilities of advancing

labor efficiency in agriculture is still very great. We are rapidly substituting the world's lightest prime mover, the internal combustion motor, for the heaviest prime mover, the animal, and we have been largely devoid of imagination. We have been trying to make a mechanical horse—a pulling unit out of the motor instead of capitalizing its great advantage, lightness. Housing —the housing of farm people, farm livestock, crops and equipment is awaiting the combined contribution of the coöperative team, the scientist and the engineer.

We are engaged in the greatest contest of arms that the world has ever witnessed. Our objective has been stated as a battle for freedom; freedom of speech, freedom of worship, freedom from fear, and freedom from want. The latter is not the least but it is for the most part freedom from famine. An interesting conference was held last year in the United States at Warm Springs, Virginia. It was the United Nations Conference on Food and Nutrition. Two significant statements came out of the conference. The first was that two-thirds of the world's population were engaged directly in the production of food—67 per cent against 18½ per cent in the United States. Second, that two-thirds, or an equal proportion, were continually hungry. Who, may I ask, may have the opportunity to contribute the largest measure of service to the hungry world? I am not unmindful of other contributions that may be made, but if the world is to have more goods and service, engineering methods which enable more to be produced must be utilized. This week a representative of the Chinese Ministry of Agriculture addressed the agricultural engineers at Milwaukee. He estimated that something like 121 million acres of additional land could be brought into production. Some of this is marginal land which must be utilized on an extensive plan if at all.

It would appear to me that solving the problem of freedom from want offers one of the greatest opportunities for service to humanity that ever came to any group of men, if it can be grasped. I ask the engineering educators present, why not consider the soundness of what I am saying, and if you find it true, as I think you must, why not give the agricultural engineer encouragement?

There are a number of agricultural engineers present. I would say to you that we should embrace the unusual opportunity of service here and abroad. Engineers serve in the production of commodities and services but the agricultural engineer serves in a most important way through the production of the most vital of the commodities the human race uses, food.

If these thoughts I have expressed have been of interest I am glad. If they may in any way enlist a greater interest among engineering educators, my reward is great.

Some Revisions of Engineering Education*

By ALAN HAZELTINE

Lately Chairman of Physics Department, Stevens Institute of Technology

My main thesis is: *The engineering course is better adapted than the liberal arts course to give a broad understanding of the modern world.* Engineering colleges have overlooked an opportunity in taking for granted that their *only* mission is to train engineers. Liberal arts teachers have too long considered themselves as the custodians of culture and have looked down on their engineering colleagues. On the contrary, we should force them to look up to us as the teachers of a fuller culture, by sending out graduates whose vision is broader and deeper than they can give. The time should come when every high-school graduate having the urge and ability for creative work, no matter in what field, should look to the engineering college for his basic training. To him, the liberal arts course should appear a little old-fashioned and too confining, rather a refuge for the intellectually less alert.

Perhaps culture can be briefly defined as an understanding of the world. Our failure to disseminate this culture widely enough is the weakness of our civilization; for we constantly hear the complaint that scientific development has outrun our ability to control it. Although our entire lives are bound up with the machines that have been provided by the scientist and the engineer, only a relatively few, even among highly educated people, have been trained to understand these machines and their relation to our way of living.

It will not do to serve young people with purely descriptive courses. The thoughts that are evoked by a description of the telephone system, an automobile, motion pictures, the radio, are not at all the thoughts of the engineers who evolved these machines. To understand our world, one must actually think as the engineer thinks—often without words but by spatial and mathematical relations that can be expressed only in drawings or graphs.

This statement may be doubted at first. Does one after all need to know how a machine works? Would it not suffice for cultural purposes merely to appreciate how its use affects our lives? To dispel this doubt, let us look further into our idea of culture. Our machine age is not characterized merely by the use of machines, but more importantly by a new mode of thought. *Precision has replaced suggestion.* In the realms of literature and art, thoughts are conveyed by suggestion: nothing is precise; nothing can be positively proved. As physical science and engineering have developed, they have become more and more rigorous and precise. Before Coulomb, electrical science was wholly descriptive; now we have carefully defined standards of measurement, as well as standard defi-

*Presented at the 52nd annual meeting, S.P.E.E. (Electrical Engineering), Cincinnati, Ohio, June 22–25, 1944.

nitions of terms and hosts of other standards for reckoning the performance of our machines. In a few hundred years, standards of length have progressed from the length of a man's foot to a gage block precise almost to a millionth of an inch; and standards of weight, from a grain of wheat to a magnitude expressible to about one part in a billion. Watt thought it a good fit when he could not drop a shilling between a piston and its cylinder; now we have great gears advertised to have their tooth surfaces precise to a ten-thousandth of an inch. A hundred years ago, heat was only a qualitative science; for, until Kelvin provided it, there was no criterion for judging whether a degree at one part of a thermometer scale was equivalent to a degree at another part. Precision in thinking, gained only by habitual application in the study of engineering, is one of the most vital elements of the culture that our young people need.

But, proponents of the liberal arts will argue, our courses recognize esthetic values; yours do not. This objection is without foundation: beauty is an element of good literature and good art; it is also an element of good science and good engineering. I would assert that a concise mathematical proof, a well conceived physical experiment, or a superbly fit engineering design, can have a higher order of beauty than can an essay or a painting. To appreciate beauty of any kind requires some education. To the initiated, does not Faraday's series of basic electrical experiments exhibit a beauty hard to match by any work in words or in paint?

Again, it may be argued that liberal arts courses have a utilitarian value as pre-professional courses for fields other than engineering. The answer to this is that already many students have found an engineering course to be a particularly good foundation for other professions. I think of a member of the clergy (now serving his country as chaplain in the Navy), a brilliant young physician, now a professor in his specialty, and an able lawyer, each of whom has credited his success to the training in precise thinking given him in the general engineering course at Stevens. More than one noted writer of fiction has had an engineering training or even has been a practicing engineer. We have been too prone to think of such cases as exceptional; they should become common.

If our main thesis be granted, the question then arises: how can a course designed primarily as a preparation for a professional engineering career be adapted as a general cultural course? My answer is: by condensing into three years our present general engineering course and then differentiating in the fourth year with special cultural courses and courses in business administration, in mathematics and the physical sciences and in the various branches of engineering. The fourth year might also include courses in biological science, for pre-medical preparation or for their own sake. This proposal is based on my secondary thesis: *with properly selected students having adequate preparation, it is possible by improved methods of presentation to cover in three years the full equivalent of what is now being accredited as a four-year course in general engineering.* To define my terms, "adequate preparation" means merely that which is now being given by the first-class high-schools and preparatory schools in New England and the Mid-

dle Atlantic States; and "properly selected" means such selection as is now practiced by most engineering colleges in this region, with perhaps somewhat more care in excluding through aptitude tests those doomed to failure in the freshman year.

It is emphatically not proposed to weaken the present general engineering course by cutting out any of the real substance, nor by substituting a descriptive presentation for a rigorous one. On the contrary, logical rigor should be one of the conspicuous features that would strike the freshman as distinguishing the college course from his high-school course. He should be told not to accept his professor's word for anything basic, but should expect to be shown the basis in observation for every physical law and every mathematical postulate, with definitions of all terms and complete derivations of the consequences of these laws, postulates and definitions.

The required condensation can easily, in my opinion, be achieved by abandoning methods of presentation which have been inherited from ages when the subjects were incompletely understood, by using the same points of view and the same terms in different departments teaching in the same field, and by correlating the work of the various departments so that subjects come to the student in logical order and without unnecessary duplication.

Lest some be incredulous, I speak from experience, having had charge of courses in electrical engineering, mathematics and physics, in each of which I wrote the text. In physics, for example, I abandoned the old-fashioned and inadequate introduction of electricity by charged particles and magnet poles and started with current electricity, with which were later incorporated dielectric and magnetic ideas; for it should be recognized that the work of Coulomb is now only of historical interest, having been completely superseded by the work of Faraday and the appreciation of conservation of energy. Thus, from the beginning, students worked with the concepts most used by electrical engineers—current, voltage, power and dielectric and magnetic fluxes. By simplifying the mathematical methods, I was able to bring down to the sophomore level subjects commonly reserved for senior or graduate courses: the laws of electric waves on lossless lines and plane waves in space were worked out rigorously with only elementary algebra; and the theory of radiation from a simple antenna or dipole was presented by elementary calculus—no use being made of partial differential equations, vector analysis, or the arbitrary assumption of retarded potentials. With this background, I was able to give an honest introduction to light as an electromagnetic wave (not the customary notion of a fictitious transverse vibration in a fictitious medium) and even to work out such a customarily advanced topic as Fresnel's laws by the most elementary relations of electric and magnetic fields, again using only algebra.

I refrain from giving other examples in mechanics, sound and thermodynamics and in mathematics. But they justify a strong conviction that our whole curriculum needs a detailed overhauling with a critical examination of the best way to present each topic, making full use of present knowledge and untrammeled by tradition.

With this conviction, we can reorganize our curriculum so as to give in three years a course which includes not only the culture of science and engi-

neering, but also appreciation of the humanities. At the end of this period, a student anxious to get into the world of affairs may properly terminate his academic training, having the advantage of a year saved at a critical period in his career. Other students will want to go further—perhaps in the humanities, perhaps in basic science, perhaps in other professions, but most often, we still hope, into our own profession, *engineering*.

Curriculum Revision at the Massachusetts Institute of Technology

By J. R. KILLIAN, JR.
Executive Vice President

Changes in the undergraduate curriculum of the Massachusetts Institute of Technology are now being made to meet special conditions which will obtain during the post-war period. These changes have taken two directions, first, the simplification of course schedules and second, revision and expansion of the humanistic part of the curriculum.

The new schedule of subjects provides for a standard curriculum for all first-year students, including those in architecture. The second-year curriculum has been divided into two subdivisions, science and engineering. Within each of these groups the second year curriculum is substantially common, with variations occurring only in the limited amount of specialized professional work included. To reduce the complexity of schedules in the professional courses, the number of undergraduate subjects is being reduced by approximately 20 per cent, by consolidation of subjects of nearly the same content and purpose and by elimination of certain options. This simplification of schedule is tentative and is designed to clear the decks for action in the post-war period so that the load on our staff and the use of our facilities will be made more favorable for handling an increased registration and special programs for veterans.

The second part of the curriculum revision permits a further development of the Institute's Division of Humanities and its curriculum in humanistic subjects. In this new program the work of the first year will be devoted to English, with special emphasis on written and oral expression. The same course will not be given necessarily to all students; those who are ready for fairly advanced composition will have an opportunity to work at their level. The work in English for foreign students will be given by the Department of Modern Languages and, when necessary, taught from the point of view of persons who are studying a second language. The emphasis on good writing and expression will continue throughout the four-year program and be emphasized in other subjects in later years.

In the second year all students will have an introductory course in modern history, with special reference to the place of the United States in world affairs. This course will serve in the first place to give the student historical perspective and a knowledge of the development of American civilization, and in the second place to further incidental training in written and oral expression.

In the third year all undergraduate students will devote the first half year

to economic principles, and the second half year to a course in introductory psychology. Students who prefer additional work in economics will have the option in the second half year to take a course in labor relations or one in industrial economics instead of general psychology.

With this background in English, history and the social sciences, every student in his fourth year will be asked to choose one of four options: (*a*) History of Science and Thought; (*b*) Fine Arts; (*c*) Introduction to Literature; and (*d*) International Relations. Each of these four courses will be closely coördinated with the objectives and purposes of those given in the preceding three years, and wherever possible, the laboratory method will be used. In the fine arts, for example, we anticipate providing opportunity for training in the methods of the graphic arts.

To take charge of the international relations option for seniors and in anticipation of a need for men trained for foreign service in the post-war period, the Institute has appointed Dr. Norman J. Padelford, formerly at the Fletcher School of Law and Diplomacy and at the present time a special consultant to the State Department, as Professor of International Relations in the Department of Economics and Social Science. Further plans are being made for providing the best obtainable instruction in the other options so that these humanistic subjects in rigor and presentation will be on the same level as professional subjects in science and engineering.

Under the new plan the system of electives known as "General Studies" formerly in effect at the Institute will be maintained but on a reduced basis. These subjects will be offered, however, as optional electives without credit. So far as possible, the subjects offered in any term and the hours and methods of instruction will be planned to meet the needs of students who request subjects of this type for the purpose of broadening their education.

New Members

AKEY, WAYNE W., Lecturer in Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, E. D. Howe.

ANDERSON, DICE R., Assistant Professor of English, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, R. S. King.

ARCHER, LUTHER B., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. A. R. Knight, E. A. Reid.

BAKER, WILFRED H., Assistant Professor of Civil Engineering, West Virginia University, Morgantown, W. Va. H. W. Speiden, G. P. Boomsliter.

BECKWITH, THOMAS G., Mechanical Engineer, Gulf Research and Development Co., Pittsburgh, Pa. F. L. Bishop, Nell McKenry.

BEECHER, MILTON F., Director of Research, Norton Co., Worcester, Mass. C. F. Scott, T. H. Morgan.

BOAG, SIDNEY F., Assistant Professor of Civil Engineering, University of Maryland, College Park, Md. R. B. Allen, H. B. Hosall.

BRADY, WILLIAM H., Lecturer in Mechanical Engineering, University of California, Berkeley, Calif. A. S. Levens, E. D. Howe.

BROWN, HAL C., Associate Professor of English, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, R. S. King.

BRYANS, ANDREW E., Assistant Professor of Engineering Drawing, Franklin and Marshall College, Lancaster, Pa. W. R. Bryans, H. M. Fry.

BURG, WALTER V., Professor and Acting Head, Dept. of Physics, University of Toledo, Toledo, Ohio. J. B. Brandeberry, I. F. Zarobskt.

BUSH, GEORGE F., Assistant Professor of Graphics, Princeton University, Princeton, N. J. F. A. Heacock, A. M. Greene.

BUTLER, N. RICHARD, Acting Head, Mechanical Engineering, Acting Director Bureau Industrial Research, Norwich University, Northfield, Vt. J. W. Ingalls, W. C. White.

CALDWELL, ROBERT G., Dean of Humanities, Massachusetts Institute of Technology, Cambridge, Mass. R. S. Williams, J. M. Bunker.

CHILDS, HERBERT R., Assistant Professor of Physics, University of Rochester, Rochester, N. Y. J. L. Hill, H. S. Gardner.

DICKINSON, JOHN L., Assistant Chief Engineer, Engineering School, Curtiss-Wright Technical Institute, Pasadena, Calif. G. C. Bauer, Alfred Jensen.

DORFMAN, LEO O., Advisory Engineer, Patent Dept., Westinghouse E. and M. Co., East Pittsburgh, Pa. A. M. Dudley, E. B. Roberts.

ELLINGSON, MARK, President, Rochester Institute of Technology, Rochester, N. Y. A. C. Harper, J. T. Faig.

EVANS, FREDERICK R., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. P. E. Kyle, A. L. Townsend.

EVANS, FREDERICK J., Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. C. B. Stanton, W. N. Jones.

FOLK, EDWIN H., Professor of English, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, R. S. King.

FORRESTER, JAMES D., Professor and Chairman, Dept. of Mining Engineering, Missouri School of Mines, Rolla, Mo. C. L. Wilson, A. C. Callen.

FOSTER, EDWARD, Instructor in English, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, R. S. King.

GIESE, HENRY, Professor of Agricultural Engineering, Iowa State College, Ames, Iowa. H. J. Gilkey, J. B. Davidson.

GREENWOOD, JOHN W., Instructor in Engineering, University of Buffalo, Buffalo, N. Y. H. P. Fullerton, H. M. Gehman.

GREGORY, FRANCIS A., Principal, Armstrong Technical High School, Washington, D. C. J. C. Webster, D. E. Howard.

HALL, ALLEN S., Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. H. A. Bolz, R. W. Leutwiler.

HANSON, ARNOLD E., Associate Professor of Industrial Education, University of New Hampshire, Durham, N. H. L. W. Hitchcock, E. L. Getchell.

HAWN, HERBERT W., Assistant Professor of Mechanical Engineering, Michigan College of M. and T., Houghton, Mich. W. C. Polkinghorn, L. A. Rose.

HENRY, LEVI L., Professor of Mechanical Engineering, Detroit Institute of Technology, Detroit, Mich. C. C. Winn, M. M. Cory.

HOWES, VICTOR E., Instructor in Engineering Drawing, Harvard University, Cambridge, Mass. C. J. Walsh, Albert Haertlein.

JETT, DANIEL B., Dean of Engineering, New Mexico A. & M. College, State College, N. M. Re-admission.

JOHNSON, STANLEY F., Instructor in History, Michigan College of M. and T., Houghton, Mich. A. K. Snelgrove, L. A. Rose.

JONNARD, AIMISON, Instructor in Chemical Engineering, Kansas State College, Manhattan, Kansas. Linn Helander, M. A. Durland.

JOSEPH, THOMAS L. Professor of Metallurgy, University of Minnesota, Minneapolis, Minn. F. B. Rowley, B. J. Robertson.

LAKE, ROBERT E., Assistant Professor of Electrical Engineering, Pratt Institute, Brooklyn, N. Y. Re-admission.

LEET, HORACE W., Professor of Mechanical Drawing and Machine Design, University of Rochester, Rochester, N. Y. Re-admission.

LONGWELL, WILLIAM F. M., Assistant Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. A. J. Knight, J. W. Howe.

MCKEON, JESSE C., Supervisor, Scholarships and Graduate Study, Westinghouse E. & M. Co., 306 Fourth Ave., Pittsburgh, Pa. H. C. Madsen, E. B. Roberts.

MIDDLEMISS, ROSS R., Associate Professor of Applied Mathematics. Washington University, St. Louis, Mo. A. S. Langsdorf, F. W. Bubb.

MILLER, PERCIVAL F., Assistant Professor of Applied Mechanics, Virginia Polytechnic Institute, Blacksburg, Va. L. O. Shaughnessy, E. B. Norris.

MILLER, WALTER H., Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Mo. H. W. Wood, Harry Rubey.

MOORE, ROBERT F., Placement Director, Columbia University, New York 27, N. Y. K. A. Meade, J. K. Finch.

NARBUTOVSKIH, PAUL, Engineer, Westinghouse E. & M. Co., Sharon, Pa. H. E. Dyche, F. L. Bishop.

NILMEIER, HERBERT P., Instructor in Civil Engineering, University of California, Berkeley, Calif. C. T. Wiskocil, E. D. Howe.

NOFFSINGER, JOHN S., Director, National Council of Technical Schools, 839 17th St. N.W. Washington 6, D. C. F. L. Bishop, A. C. Harper.

OLITT, ARNOLD, Associate in Civil Engineering, University of California, Berkeley, Calif. C. T. Wiskocil, E. D. Howe.

PERRY, JOHN P. H., Vice President, Turner Construction Co., 420 Lexington St., New York City. H. S. Rogers, F. L. Bishop.

PERRY, RAYMOND J., LT., Instructor in Chemical Engineering, U. S. Coast Guard Academy, New London, Conn. C. E. Tucker, C. E. Dimick.

PITT, RAYLEIGH ST. C., Lecturer in Mechanical Engineering, University of Western Australia, 24 Wavell Rd., Nedlands, W. A. F. L. Bishop, Nell McKenry.

POWERS, LOUIS J., Associate Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas. J. H. Murdough, H. F. Godeke.

POWER, ROY B., Lecturer, Harvard University, Cambridge, Mass. C. L. Dawes, C. J. Walsh.

PUTNAM, GERALD, Assistant Professor of Graphics, Massachusetts Institute of Technology, Cambridge, Mass. D. P. Adams, R. D. Douglass.

RAINEY, GLENN W., Associate Professor of English, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, R. S. King.

RAUDEBAUGH, ROBERT J., Assistant Professor of Metallurgical Engineering, University of Rochester, Rochester, N. Y. J. L. Hill, J. J. Martin.

RODES, HAROLD P., Lecturer in Mechanical Engineering, University of California, Berkeley, Calif. E. D. Howe, A. S. Levens.

RODMAN, GEORGE E., Instructor, Industrial Relations Dept., Commonwealth Edison Co., 72 West Adams St., Chicago, Ill. J. E. Hobson, M. B. Reed.

ROGERS, FRANKLIN C., Assistant Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. P. H. Daggett, F. C. Miragain.

RUDENBERG, REINHOLD, Professor of Electrical Engineering, Harvard University, Cambridge, Mass. C. L. Dawes, H. M. Westergaard.

SAIDLA, LEO E. A., Associate Professor of English, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. D. F. Othmer, E. F. Church.

SCHLESINGER, GEORG, Director of Engineering, Institution of Production Engineers, London, England. G. A. Stetson, F. L. Bishop.

SEDGEWICK, CHARLES H. W., Associate Professor of Mathematics, University of Connecticut, Storrs, Conn. F. P. Fischer, G. S. Timoshenko.

SINGSTAD, OLE, Chief Engineer, New York City Tunnel Authority, 200 Madison Ave., New York City, C. F. Scott, A. B. Parsons.

SPENCER, ERNEST L., Assistant Professor of Civil Engineering, Northeastern University, Boston, Mass. E. A. Gramstorff, W. C. White.

STILLWELL, HENRY S., Head, Aeronautical Engineering, University of Kansas, Lawrence, Kansas. J. O. Jones, W. C. McNown.

STOUT, LAWRENCE E., Professor and Head, Dept. of Chemical Engineering, Washington University, St. Louis, Mo. Jules Bebie, A. S. Langsdorf.

SWANTON, WALTER F., Instructor in Industrial Chemistry, Rochester Institute of Technology, Rochester, N. Y. M. S. Ketchum, G. B. Earnest.

TAULBEE, PRESTON J., Instructor in Science, U. S. Coast Guard Academy, New London, Conn. C. E. Tucker, C. E. Dimick.

TAYLOR, HAROLD E., Acting Principal, Brooklyn Technical High School, 29 Ft. Greene Place, Brooklyn 1, N. Y. F. L. Bishop, Nell McKenry.

VEZEAU, WALDO A., Assistant Professor of Mathematics, University of Detroit, Detroit, Mich. C. J. Freund, C. A. Lingeman.

WARDELL, ARTHUR, Assistant Professor of Engineering Drawing, University of Toronto, Toronto, Ont. W. J. T. Wright, C. R. Young.

WESTFALL, ALFRED, Professor of English, Colorado State College, Fort Collins, Colo. G. F. Henry, J. T. Strate.

WORRELL, DONALD T., Instructor in Mechanics, West Virginia University, Morgantown, W. Va. G. P. Boomsliter, C. H. Cather.

WYKES, STANLEY A., Assistant Professor of Industrial Engineering, Virginia Poly. Inst., Blacksburg, Va. P. T. Norton, W. G. Ireson.

College Notes

Polytechnic Institute of Brooklyn.—The list of ESMWT courses given at the Polytechnic again includes two lecture and two laboratory courses of Graduate level in the field of Ultra-Short Waves and Cathode Rays. These courses, which are given in the evenings, draw students principally from the electronics industries in the metropolitan area. They provide means for engineers in practice to acquire graduate training necessary for their work without loss of working time and also without expense. After two years, attendance in this program continues to demonstrate its popularity.

The complete listing of ESMWT courses at the Polytechnic includes one course in aeronautical engineering, 4 courses in Civil Engineering, one in drafting, 20 in electrical engineering, 51 in mechanical engineering, and 2 in physics.

University of Illinois.—W. L. Everitt, one of America's foremost authorities on electronics, has been appointed professor and head of the department of electrical engineering. Because Dr. Everitt has been directing important research for the Army at Washington since early 1942, he was granted an automatic leave of absence from Illinois to continue his Army work and will take up his duties at the University immediately on release from war service.

Prior to going to the Army as chief of operational research in the office of the chief signal officer, Dr. Everitt had since 1934 been professor of electrical engineering at Ohio State University. He previously had been an instructor at Cornell University and the University of Michigan.

He is the author of several books and a number of technical magazine articles on radio and telephone communications; has served as research and consulting engineer to the American Telephone and Telegraph Co. and various manufacturing concerns, and is the inventor of a number of electronic devices. He is a fellow and a director of the Institute of Radio Engineers and a fellow of the American Institute of Electrical Engineers.

As head of the department of electrical engineering, Dr. Everitt will succeed Ellery B. Paine, whose retirement was announced recently.

Mass. Institute of Technology.—William E. Stanley, formerly professor of sanitary engineering at Cornell University, and well known as a consulting sanitary engineer, has been appointed professor in charge of sanitary engineering courses in the department of civil and sanitary engineering. Professor Stanley recently returned from North Africa where he served as a Major in the Corps of Engineers and had assignments as Water Supply Officer for seven months during the North African Invasion and the Tunisian Campaign and Chief of Construction in the Service of Supply for eight months.

The appointment of Professor Stanley is part of a plan to expand the

program in sanitary engineering to meet the anticipated post-war demand for sanitary engineers needed in the development of public health facilities, the abatement of stream pollution, the operation of water and sewage treatment plants and the treatment of industrial wastes.

Frederick J. Adams and Lawrence B. Anderson have been promoted from associate professors to professors on the faculty of the School of Architecture and Planning.

Michigan College of Mining and Technology.—The total fall-term enrolment is 548 men and women, including approximately 75 off-campus students in the ESMWT program but excluding registrants in the adult-education program referred to below. Regular students number 195. Sixteen cadet nurses are also taking some of their academic work at the college. The other students consist of 264 Army Air Forces Enlisted Reservists, 194 of them in their second term and 70 in their first.

The adult-education program is a new departure for the college. It is carried on under the provisions of an act of the special session (January, 1944) of the State Legislature, which appropriated $250,000 to be expended for experimental work of this sort throughout the state between July and December 31, 1944. Michigan Tech, in conjunction with the Northern Michigan College of Education, is in charge of the project in the Upper Peninsula of Michigan, with Dr. James Fisher as director.

On July 1, Dr. James Fisher retired from the deanship which he had held since 1936 and from the headship of the Michigan Tech department of mathematics and physics, which he had held since 1901. He now heads the college's Extension Division, which administers not only the adult-education program but the ESMWT curriculum, the college's municipal-planning consultancy service, and shops training.

Upon his retirement from active teaching, Associate Professors John M. Harrington and F. L. Partlo were promoted to professors and assigned the headships of the department of mathematics and the department of physics respectively. Other men promoted in those departments, all from assistant to associate professors, are Carl Knaebel, William A. Longacre, and Thomas C. Sermon. Additional promotions to associate professorships went to Messrs. A. N. MacIntosh (geological engineering) and E. J. Townsend (economics), Dr. Ralph Menzel (chemical engineering), Herbert W. Hawn (mechanical engineering) and William B. Gertz (metallurgical engineering). Fred P. Hanselmann was advanced from instructor in languages to assistant professor.

In immediate charge of ESMWT, as institutional representative and coordinator, is Professor MacIntosh. The municipal-planning consultant is Professor Townsend, who has been officially designated by the State Planning Commission as its field representative in the Upper Peninsula. He has been in close contact with nearly one hundred governmental agencies, including all Upper Peninsula counties and cities, many other municipalities, several county road commissions, and a number of school districts.

The State Planning Commission of 15 men—one of whom is President Grover C. Dillman of the college—met jointly at Michigan Tech on August 18 with the Commission's Upper

Peninsula Technical and Industrial Subcommittee, which is headed by Dr. Dillman and which includes among its members the college's entire research committee. The Governor and other state officials attended.

Assistant Professor Edwin Spacie, who had been on leave since May 1, was recalled to the college September 21 to take the newly-created position of student counselor. He will work in conjunction with the registrar's department, and will be aided by two faculty committees first set up last winter—the Veterans Advisory committee and the Foreign Students committee—as well as by the older Student Advisory committee.

Appointment of a committee of the Michigan Tech SPEE Branch to study the recent Hammond report and to aid the Postwar Plans, Curriculum, and Executive committees in revision of the curriculum, is explained in more detail elsewhere in this issue, in the report of the college branch.

The Board of Control has authorized the establishment of an assistantship in Engineering English for men interested in obtaining "interne" training in that important subject. The assistantship is for a nine-month period. The holder will audit certain courses in engineering methods and engineering economics, participate actively in the work of the SPEE branch, acquaint himself with major curricular and instructional problems facing secondary-school as well as college teachers of English, and assist in the editing of technical papers and, under direction, in the teaching of technical English.

The State Administrative Board has authorized the expenditure of $22,750 to purchase a tract of land for a new auditorium. The New Amphidrome, acquired somewhat over a year ago by the college as a winter-sports building, has been officially renamed the James R. Dee Stadium. Mr. Dee, a resident of Houghton who recently observed his eighty-eighth birthday, was a pioneer in introducing and fostering hockey and other winter sports in the Copper Country.

Rochester Institute of Technology.—The Board of Regents of the University of the State of New York has approved the petition to change the name of the Rochester Athenaeum and Mechanics Institute to the Rochester Institute of Technology as of September 1st, 1944.

University of Texas.—M. V. Barton, Professor of Aeronautical Engineering at The University of Texas, is on leave of absence to participate in a coöperative program with the Douglas Aircraft Company, of Santa Monica, California. Dr. Barton is engaged in productive assignments in the Engineering Department, particularly in structures and in vibration and flutter. This coöperative program was developed by C. T. Reid, Manpower Assistant to A. E. Raymond, Vice President in charge of Engineering for Douglas, and M. J. Thompson, Chairman of the Department of Aeronautical Engineering at The University of Texas. The program represents one of the pioneering efforts to provide for closer relationships between industry and education, from which engineering instructors and industrial personnel may obtain a better understanding of their mutual problems.

Necrology

CHARLES HOMER BAXTER

1879 – 1944

Charles Homer Baxter, Professor and Head of the Civil and Mining Engineering Department of the Michigan College of Mining and Technology, passed away July 29, 1944, at his home, 1407 College Avenue, Houghton, Michigan.

Professor Baxter was born in Detroit, Michigan, February 12, 1879. Following graduation from the public schools of Detroit he entered the Michigan College of Mines in the Fall of 1899, graduating with the degrees of B.S. and E.M. in 1902.

Following graduation he was engaged in mining engineering work for the Quincy Mining Company, Hancock, Mich.; the Republic Iron and Steel Company, Negaunee, Mich.; and in civil engineering work for Dickinson County, Mich.

Three years after his graduation he returned to the college, for one year, as an instructor in the Civil and Mining Engineering Department. The following year he spent in examining and reporting on properties mostly in the West and Southwest United States, for the Jones Exploring Company, of Iron Mountain, Mich. In the Fall of 1907 he became superintendent of the Loretto Iron Company in Iron County, which position he held for twenty years.

In 1927, he again returned to the college as elected professor and head of the department of civil and mining engineering, succeeding the late Professor F. W. Sperr. This position he held until the time of his death.

In addition to his duties as superintendent and professor, he took an interest in public and civic affairs and also did considerable consulting and technical work. While at Loretto he served as township supervisor, president of the school board, member of the State tax commission, and director of several industrial organizations. He was also a co-author of an authoritative book on Mine Examination and Valuation.

Professor Baxter served as President of the Alumni Association of the Michigan College of Mines, President of the Lake Superior Mining Institute, Secretary of the Lake Superior Section of the American Institute of Mining and Metallurgical Engineers, and President of the Houghton Rotary Club.

Division of Educational Methods

At the Cincinnati meeting last June the Executive Council authorized the formation of a new Division. The work of this Division has been organized under three committees:

Committee on Teaching Techniques,	Scott B. Lilly, Chairman, Chairman, Division of Engineering, Swarthmore College, Swarthmore, Pa.
Committee on Visual Aids,	John I. Yellott, Chairman, Director, Institute of Gas Technology, affiliated with Illinois Institute of Technology, Chicago, Ill.
Committee on Examinations,	Carl L. Svenson, Chairman, Member-Secretary, Texas State Board of Registration for Professional Engineers, Austin, Texas.

If those members who are especially interested in the activities of the Division will inform the Secretary, their names will be placed on a mailing list to receive circular literature that may not appear in the Journal.

R. H. FRAZIER, Chairman, Mass. Inst. Technology,
W. R. BRYANS, Vice Chairman, New York University,
G. S. TIMOSHENKO, Secretary, Univ. of Connecticut, Storrs, Conn.